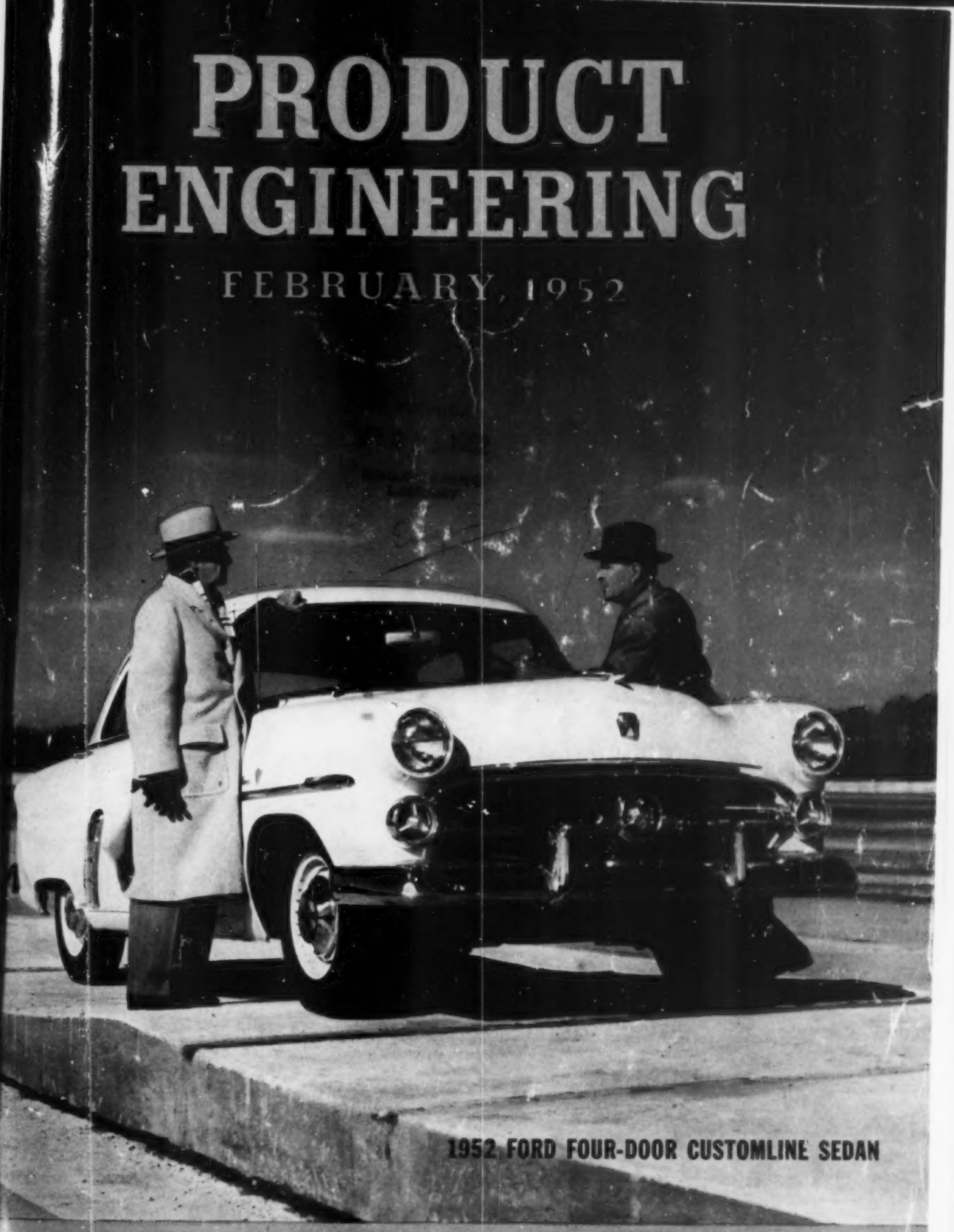
PRODUCT ENGINEERING

FEBRUARY, 1952



1952 FORD FOUR-DOOR CUSTOMLINE SEDAN

IN THIS ISSUE—Military Finishes • Rubber Base Adhesives • Electric Clutch and Brake Controls • Nylon for Ball Bearings • Dip Brazing Aluminum Alloys

A McGRAW-HILL PUBLICATION
FIVE DOLLARS A YEAR

Multiply by 560,000....

SHARON* STEELS PLAY BIG PART IN "10,000-CAR-A-MONTH" PROGRAM

Today America is moving more goods than ever before. To do the job the nation's railroads are operating the greatest rail system ever devised. Since the close of World War II more than 400,000 new freight cars have been added, and on order — 160,000 more — at a rate of 10,000 per month.

All this requires steel in immense tonnages — important parts of it come from the mills of Sharon Steel—a major supplier to the railroad car building industry for more than 50 years.

*Specialists in STAINLESS, ALLOY, COLD ROLLED and COATED Strip Steels.

SHARON STEEL CORPORATION

Sharon, Pennsylvania

DISTRICT SALES OFFICES: CHICAGO, ILL., CINCINNATI, O., CLEVELAND, O., DAYTON, O., DETROIT, MICH., INDIANAPOLIS, IND., MILWAUKEE, WIS., NEW YORK, N. Y., PHILADELPHIA, PENNA., ROCHESTER, N. Y., LOS ANGELES, CALIF., SAN FRANCISCO, CALIF., MONTREAL, QUE., TORONTO, ONT.

For information on Titanium Developments contact Mallory-Sharon Titanium Corp., Indianapolis 6

SHARONSTEEL

VOLUME 23 — PRODUCT ENGINEERING — NUMBER 2

G. F. NORDENHOLT, *Editor*
Assistant to the Editor, Joseph Kerr • *Managing Editor,* V. H. Laughner
Associate Editors, J. D. Cooney, E. S. Cobb • *Assistant Editors,* P. J. Rochford, R. P. Dominic, N. J. Van Ness, C. R. Tobin • *Editorial Assistants,* P. N. Anderson, B. K. Ledgerwood, L. H. Young
Consulting Editor, Robert E. Bruckner • *Washington,* George B. Bryant, Jr.
Assistant Publisher, W. E. Kennedy • *Advertising Sales Mgr.,* Stanley J. Alling • *Service Mgr.,* Hugh Britton
Publisher, Albert Hauptli
Foreign News Bureau: London • Paris • Berlin • Moscow • Tokyo • Melbourne • Rio de Janeiro • Buenos Aires • Manila

FEBRUARY 1952

Now: Nylon Parts for Ball Bearings by F. W. Recknagel 119
Quietness and corrosion resistance are but two of the reasons for using nylon races and ball cages.

The Electronic Flip-Flop as a Machine Element by John B. Flynn 124
Electronic counters are being used increasingly in the control circuits of high speed machines.

Engineering Uses for Rubber Adhesives by R. S. Piper 120
The selection of rubber adhesives in engineering and methods of adhesive application.

Resistance Wire Computer by C. V. Ramamoorthy and W. W. Soroka 134
Construction and operation of an inexpensive linear simultaneous algebraic equation solver.

Modern Control Circuits for Electric Brakes and Clutches by Andrew H. Decker 138
A discussion of various brake control circuits and their influence on performance of the unit.

Product Designs 144
Design features of 1952 cars: Willys, Buick, Ford, Lincoln, Mercury, Packard.

Eleven Ways to Oil Lubricate Ball Bearings by D. L. Williams 166
Systems are illustrated and described for different operating conditions and types of installations.

What You Should Know About Hard Rubber by A. J. Lorenz 168
Engineering properties, applications and design possibilities of hard rubber products.

Flux Bath Dip Brazing of Aluminum Alloys by D. Wallace 173
Factors that influence joint strength and selection of filler alloys.

Elastic Elongation of Chains by L. H. Whitney and P. M. MacDonald 176
First published data for calculating the elastic elongation of three types of roller chains.

Hydraulic Noise Reduction by Piston Pump Modification by G. W. Louthan 178
Analysis of piston pump design as a source of hydraulic noise and how it can be corrected.

Phosphate Coatings for Military Products by Norman P. Gentieu 183
Review of military requirements for application of protective chemical coatings to metal surfaces.

Using the Patent Office Files as a Design Source by Charles E. Balleisen 191
The author proposes a method for keeping informed of the design data that are available from patents.

Design Charts for Large Compression Springs 203
Simplifies design of springs made from round bars ranging in diameter from ½ to 2¼ inches.

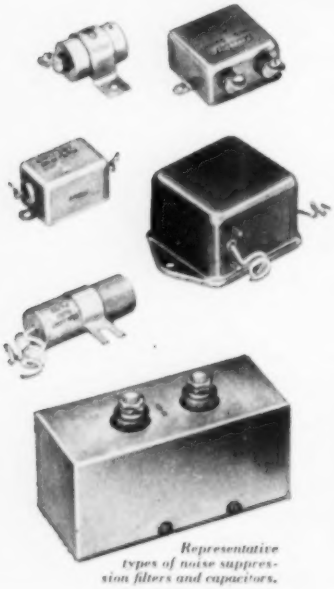
Highlights	5	Technical News	195	Engineering Abstracts	250
Front Cover	9	New Parts and Materials	208	Sans Souci	264
Available Materials	113	New Catalogs and Bulletins	222A	Our Readers Say	268
Editorial	117	Meetings	249	New Books	282

February, 1952 — **PRODUCT ENGINEERING** — **Vol. 23, No. 2**

Published monthly by McGraw-Hill Publishing Company, Inc., James H. McGraw (1860-1948), Founder. **Publication Office, 99-129 North Broadway, Albany 1, N. Y.**
Executive, Editorial and Advertising Offices: McGraw-Hill Building, 330 W. 42nd St., New York 36, N. Y. Curtis W. McGraw, President; Willard Chevalier, Executive Vice-President; Joseph A. Gerardi, Vice-President and Treasurer; John J. Cooke, Secretary; Paul Montgomery, Senior Vice-President, Publications Division; Ralph B. Smith, Editorial Director; Nelson Bond, Vice-President and Director of Advertising; J. E. Blackburn, Jr., Vice-President and Director of Circulation.
Subscriptions: Address correspondence to Product Engineering—Subscription Service, 99-129 N. Broadway, Albany 1, N. Y., or 330 W. 42nd St., New York 36, N. Y. Allow ten dayys for change of address. **Please indicate position and company connection on all subscription orders.**
Branch Offices: ATLANTA, R. M. Maultsby, 1311 Rhodes-Haverty Bldg.; BOSTON, M. A. Williamson, Jr., 1427 Statler Bldg.; CHICAGO, Anson E. Meanor, 520 N. Michigan Ave.; CLEVELAND, A. F. Tischer, 1510 Hanna Bldg.; DALLAS, J. H. Cash, First National Bank Bldg.; DETROIT, P. G. Weatherby, 856 Penobscot Bldg.; LOS ANGELES, H. L. Keeler, 1111 Wilshire Blvd.; NEW YORK, J. A. McGraw and D. C. McGraw, Jr., 330 W. 42nd St.; PHILADELPHIA, David G. Jones, Architects Bldg.; PITTSBURGH, A. F. Tischer, 738-9 Oliver Bldg.; SAN FRANCISCO, R. E. Dorland, Jr., 68 Post St.; WASHINGTON, National Press Bldg.; LONDON, Aldwych House, Aldwych, W. C. 2, England.
Single copies 50¢. United States and possessions, $5 for one year, $8 for two years, $10 for three years; Canada, $6 for one year, $10 for two years, $12 for three years; Latin American countries, $15 for one year, $25 for two years, $30 for three years; all other countries $20 for one year, $30 for two years, $40 for three years. Entered as second class matter August 21, 1936, at the Post Office at Albany, N. Y., under act of Mar. 3, 1879. Printed in U. S. A. Copyright 1952 by McGraw-Hill Publishing Co., Inc.—All Rights Reserved.

A McGRAW-HILL PUBLICATION
ABP ABC
Member of Associated Business Publications and Audit Bureau of Circulations

When electrical noise suppression is a problem . . .
put MALLORY'S specialized skills to work for you



Representative types of noise suppression filters and capacitors.

You can turn to Mallory with complete confidence when you need help in meeting the rigid electrical noise suppression requirements for military equipment.

Mallory personnel, facilities and experience which helped many manufacturers beat this problem during World War II are at your service today . . . ready with the filters and capacitors . . . ready, too, with application "know-how" essential to satisfactory noise suppression in your equipment.

And since the war, Mallory has worked steadily on noise suppression problems created by the ever-increasing use of electronic equipment by our Armed Forces.

Put Mallory's specialized skills and experience to work for you whenever you need standard filters and capacitors to meet Signal Corps and Ordnance specifications . . . or when you need special types for unusual uses. Call or write Mallory today.

P. R. MALLORY & CO. Inc.

MALLORY

SERVING INDUSTRY WITH

Electromechanical Products—Resistors • Switches • TV Tuners • Vibrators
Electrochemical Products—Capacitors • Rectifiers • Mercury Dry Batteries
Metallurgical Products—Contacts • Special Metals • Welding Materials

P. R. MALLORY & CO., INC., INDIANAPOLIS 6, INDIANA

For information on Titanium Developments contact Mallory-Sharon Titanium Corp., Niles, Ohio.

Highlights

When requesting further information from companies and organizations mentioned in the items below, confusion can be avoided by referring to the issue of Product Engineering in which items appear

NONMETALLIC MATERIALS

BLACKOUT LEGIBILITY of radioactive phosphers is satisfactory for illumination of instrument dials at ordinary reading distances, according to tests at Office of Naval Research. Other studies show phosphorescent materials are best for large areas of a few hours' visibility.

PLASTICS, principally polyester resin reinforced with Fiberglas, are appearing in some of Boeing's late model planes. They take the place of aluminum alloys in the fuel vent system, junction boxes, heating and ventilating ducts, and in safety equipment. Many mock-up parts are machined from the easy-to-work plastic, thereby cutting tool costs appreciably.

VACUUM TUBE AMPLIFIERS used in electronic circuits may be replaced by barium titanate, a material best known for its piezo-electric properties that make it suitable for crystal phono pick-ups. Study by the Army Signal Corps reveals it has a high dielectric constant at high frequencies and has an electrical "memory" characteristic useful in electronic computers.

MAGNETIC RUBBER made in the form of bands for use on recorder drums is a neoprene base pigmented with a magnetic oxide. Lubricant in base material prevents excessive wear in the recording head, yet machanical compliance of rubber with the head insures high fidelity. Brush Development Co. and Bell Labs are the developers.

GLASS FIBERS have been used before with plastics, but parts have been made only in laminate form. With Libbey-Owens-Ford's new Plaskon alkyd, a part is molded in a single piece. During the molding operation, the glass fibers line up in the part to produce good over-all strength. Or with a special mold design, the fibers will concentrate in one place to beef up a section that has to carry a disproportionate amount of stress.

GREENISH-TINT GLASS reduces the intensity of solar radiation by absorbing some of the heat in sunshine without sacrificing light transmission. Pittsburgh Plate Glass Co.'s new Solex material can be bent, laminated or tempered for use in most types of flat glass applications. Some automakers are already using the new glass.

ELECTRICAL EQUIPMENT requiring extra thin heat insulation may find the answer in Irvington, (N. J.) Varnish & Insulator Co.'s silicone-resin-coated Novabestos. Only 0.0003 in. thick, the sheet is stable at 180 C; has a long-fiber structure that results in good physical properties.

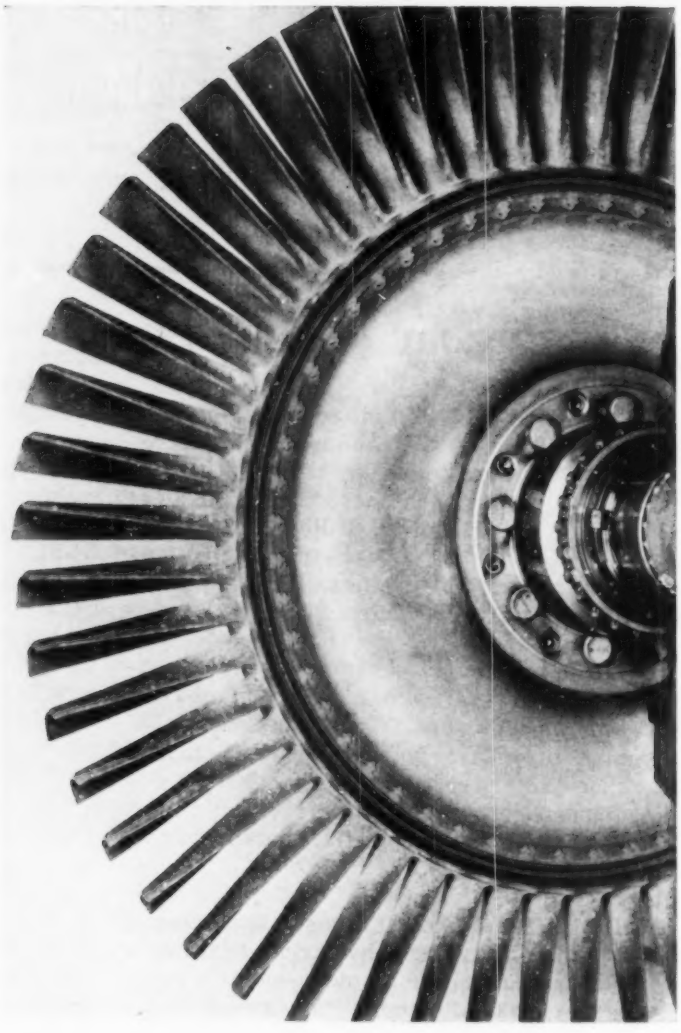
METALLIC MATERIALS

COST OF DIE CASTINGS, particularly those made of zinc and aluminum, as well as large plastic moldings, may drop a bit if Carpenter Steel's Super Samson high-strength die steel is used. Cold hobbing characteristics are same as for standard hobbing irons, yield strength at 800 F is 146,500 psi, and hardenbility is uniform throughout sections up to 4 in. thick.

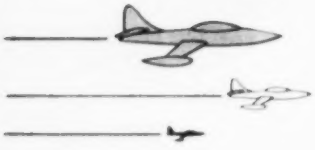
RED BRASS that can be rolled, forged and extruded as well as cast may take over in some applications where yellow brass is used. For wrought parts, the red material combines well with red bronze castings. U.S. Patent 2,577,426, assigned to Bohn Aluminum and Brass Corp. of Detroit, lists the composition as 53 percent copper and 42 percent zinc, plus Pb, Al, Mn, Si and iron.

RESEARCH at the American Viscose Corp. has resulted in the development of two new materials: Ferrolum (lead-clad steel) and Cupralum (lead-clad copper). These materials can be produced on automatic cladding machines and are expected to find usage in the chemical and nuclear industries where the higher strength of the basic materials, combined with the corrosion resistance and shielding capacity of lead are desirable. The two products are made by Knapp Mills of N. Y.

(continued on page 7)



UTICA HELPS



BY FORGING EXTRA "*FIGHT*" INTO TURBINE BLADES

Here's the turbine assembly of Pratt & Whitney Aircraft's great J-42 Turbo-Wasp—first jet engine to attain official rating for 1,000 hour overhaul.

Take a particular look at the turbine blades, photographed after 500 hours of actual operation. Besides contributing to the general service dependability of the J-42, they have another remarkable story all their own.

Combat pilots in Korea report that these blades, operating at 12,000 rpm and at extremely high temperatures, have taken damage from bullets and rocks without serious impairment of engine performance – and brought plane and pilot safely back to base.

The forging of rugged blades like these is the type of work we're doing here at UTICA. We're proud that UTICA was one of the earliest primary suppliers of turbine blades to Pratt & Whitney Aircraft for the Turbo-Wasp.

UTICA DROP FORGE & TOOL CORPORATION, Utica 4, New York

TIPS ON CONSERVATION of non-ferrous metals have been offered by a spokesman for the German Iron and Steel Institute: (1) Use of chemically polished and electrolytically brightened aluminum (99.998 percent pure)obtained from scrap by electrolysis in place of chromium and nickel; (2) production of high-purity magnesium by distillation from available scrap aluminum-bearing magnesium alloys; and (3) use of plastics and light metal alloys in place of tin.

FIRST AUTOMOBILE to be produced in Spain since the war makes extensive use of the various light alloys. Crankcase for the V-eight engine is a single light alloy casting; the two cylinder heads are cast from aluminum alloys with insert valve seats, while the pistons and crankshaft caps are forged from aluminum alloy.

COMPONENTS

CENTER-OF-GRAVITY MOUNT worked out by GE's Control Dept. engineers reportedly resists vibrations in all modes of mounting and has constant characteristics throughout wide temperature range. Four laminated phosphor-bronze spiral springs with copper braid sleeves are located at the corners of a movable base so that the inner ends of the springs are equi-distant and in the same plane as gravity center of device protected.

AN ATOMIC BATTERY using radioactive material as the energy source has been developed by Ohmart Corp. of Cincinnati. These cells will be used with a new line of instruments for measuring radioactivity. Very little current, about three micro-amp, is generated, but it's enough for measurement purposes.

SPLIT-FLANGE CLAMP simplifies connections in hydraulic systems. Hex-headed bolts through the ends of the semi-circular halves pull the parts together against an O-ring seal. Engineers at Anchor Coupling Co., Libertyville, Ill. do not use tapered threads in their assemblies that fit lines of diameter from a half to two inches.

SMALL PRESSURE SWITCH made by Manning, Maxwell and Moore, Inc. will operate continuously in range from 500 to 3,000 psi. A Teflon diaphragm permits its use with almost anything from water to nitric acid. Units are supplied in various pole-throw combinations and capacities

ZINC ALLOY RIVETS for low-stress applications and areas where corrosion is a problem are being marketed by the Gries Reproducer Corp. of New York City. The rivets are made in tubular and semi-tubular types with oval, flat or countersunk heads; can be applied with hand tools or machine; and are available in diameters from 1/16 to 9/64 in. and lengths up to 6/16 inch.

A 360 DEGREE CIRCLE OF FIRE from a round center electrode in a new spark plug is reported to improve combustion in internal combustion engines. Circ-O-Fire Spark Plug Co. of Detroit, claims the plug lasts four to seven times longer than many plugs having individual side electrodes.

NEW SERIES of fuel purging valves with built-in heating elements and over-heat thermostats to meet low temperature conditions has been announced by Pacific Airmotive Corp., Burbank, Calif. Of the "sniffle" type, valves permit air flow in both directions. Outflow from tank is determined by preset restricted setting, while inflow is nearly unrestricted so that any tendency toward forming a vacuum is relieved.

PROCESSES

CORROSION RESISTANCE of copper is combined with the strength of steel in the Ulmer bonding process developed jointly by the Automatic Gasflux Co. and the Superior Flux and Mfg. Co. of Cleveland. Large sheets of the bimetal can be deep drawn or otherwise deformed without damage to the bond. Many products built of solid copper can now be made of the clad material without sacrificing quality or efficiency.

WORN PARTS such as diesel crankshafts, cylinder liners and pump plungers can be made to last three to five times longer than usual according to the Van de Horst Corp. of Olean, N. Y. Their Vanderloy M process plates pure iron to a depth three times that obtained with a chrome plate.

RADIOACTIVE METAL BARS can be sectioned electrolytically instead of by ordinary methods that require an operator. Two professors working under AEC grant at Columbia University have cut 5/8-in. dia bars in a 24 hr period. They point out that an advantage of this method is the absence of stresses in the metal surface.

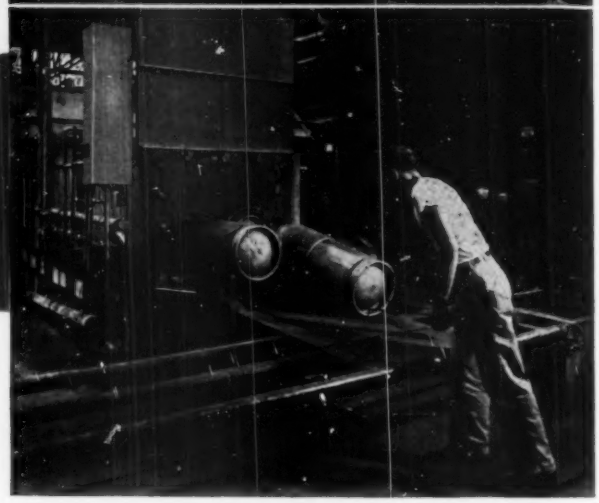
(continued on page 9)

Metallurgical furnace investigations in the laboratory influence heat processing in manufacture.

Laboratory-proved techniques

assure the

factory-made quality



of

SCAIFE

pressure vessels and deep-drawn shapes

To meet industry's ever-advancing needs for pressure vessels and deep-drawn shapes of lighter weight, higher strength, greater dependability and longer life, Scaife maintains constant research and engineering studies of materials, methods and products.

The findings of these research programs are used by Scaife engineers in the design and production of vessels to give them the qualities needed to meet the requirements of the particular service for which they are built.

The name SCAIFE on pressure vessels and deep-drawn shapes means highest quality and most advanced design.

Starting with a circular sheet of steel—
a cup is formed by a conventional drawing operation.
A continuation of this pressing operation turns the cup "inside out" without removing it from the dies,
completing—in a single stroke—the deep-drawn shape.
Deep-drawn shapes made by the Scaife reverse-draw process (described above) have uniform wall thickness throughout the entire length of the draw. Can be made in various lengths, diameters and symmetrical shapes.
Scaife cylinders are used for liquefied petroleum gases, freon, acetylene, sulfur dioxide and other materials. They are light in weight, strong and durable.
Scaife pressure vessels for air, gases and liquids are made in standard and special designs and for various types of service.

Makers of Pressure Vessels for Air, Gases and Liquids

Scaife Company

OAKMONT (PITTSBURGH DISTRICT), PA.

100 PERCENT SOLIDS in the form of thermosetting copolymers that withstand extreme pressure and temperature make effective sealants for sand castings that must be pressure tight. Western Sealant, Inc. of Culver City, Calif., claim their impregnant does not "bleed" to form a brownish residue. Technique is best suited for use on aluminum and magnesium castings.

ARGON ARC WELDING of magnesium-bearing aluminum alloy plates is the subject of a recent study at the British Aluminium Co. Ultimate strength of joints is appreciably higher than obtained by the metallic arc tichnique. A water-ccoled tungsten torch is used with the welding rod held at a small angle. The latter, of course, makes welding of recesses difficult.

DRILLING, GRINDING, milling and threading of tungsten into complex shapes on ordinary metal working machines has been announced by Philips Labs, Inc. of Irvington, N.Y. Tolerances are said to be comparable to those held on steel and brass. Electron tube and bulb makers should benefit by this significant development.

TESTING

100,000 FRAMES PER SECOND is the speed of a camera designed by C. D. Miller and A. Scharf of Battelle Memorial Institute. All photographs are taken through the same lens from the same viewpoint, thereby avoiding distortion of objects from frame to frame. Camera can be used to photograph luminous or non-luminous objects as well as for direct photography, shadowgraphs or schlieren studies. An F/2 lens opening can be set.

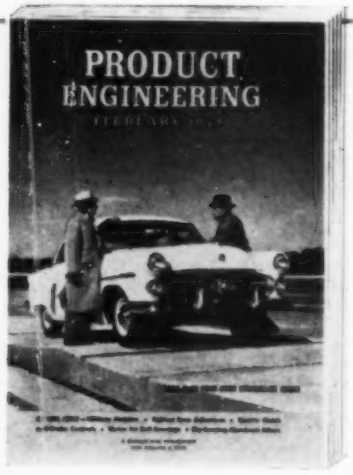
LEAVES ON SNOW absorb sunlight, become heated and melt, leaving their exact imprint. The same principle is used by the Minnesota Mining & Mfg. Co. in the new Thermo-Fax duplicating machine. Heat- and light-sensitive paper is put over a drawing and the two left under infrared light for 15 sec. Result is a clear sharp print.

A MANUAL of standards illustrates types of defects in Al and Mg castings. Objective, according to Naval Ordnance Lab, is to promote use of standard terminology and to help in interpreting radiographs.

NINE SOURCES OF DATA representing vibration, pressure, velocity, strain or other phenomena can be recorded simultaneously on a new 5 x 5 x 8-in. oscillograph perfected by Consolidated Engineering Corp. of Pasadena, California. Operating on 28-v d-c, the compact test instrument is suited to mobile testing programs where space and weight saving are of paramount importance.

A LOW-POWER ATOMIC REACTOR has been designed at North American Aviation, Inc. as part of the national program of the Reactor Development Div. of the AEC. One of the major features of the design is safety. It can be used on a university campus or in the center of any metropolitan area. Unit is now undergoing exhaustive component development and testing.

COLOR CHART includes all the color-coding requirements of electronic industry. Prepared by Globe-Union, Inc., Centralab Div., Milwaukee, Wis., chart has more than 3,000 color dots or marks that should be of value to electronics engineers, research and educational laboratories



THIS MONTH'S COVER

Earle S. MacPherson, chief engineer, Engineering Staff, Ford Motor Company, and W. E. Burnett, assistant Ford passenger car engineer, examine the new one-piece, curved windshield on the 1952 Ford Customline four-door sedan at the company's Test Track in Dearborn, Mich. Increased visibility, both front and rear, are outstanding features of the new Fords. Details of the Lincoln and Mercury, as well as other new '52 models, are featured in the special Product Design Section on pages 138 to 159 inclusive.

Cork-and-Rubber Gasket Materials made to meet government specifications

There is an Armstrong material made to meet each of the 6 types included in the principal government specification covering cork-and-rubber gasket materials. These materials are listed below. For detailed information about these compositions, please see Sweet's file for product designers or call the nearest Armstrong office listed below.

Government Specification		Armstrong Material
MIL-G-6183	Type I Soft	NC-709
	Type I Medium	NC-710
	Type I Firm	NC-711
	Type II Soft	DC-167
	Type II Medium	DC-100
	Type II Firm	DC-113
MIL-T-6841		DK-153 or RK-304S
MIL-G-6747		DK-149

New cork-and-rubber compounds. Armstrong's Research Laboratories are ready to develop cork-and-rubber materials to meet new military requirements as they arise. Please discuss your needs with your nearest Armstrong representative . . . or write.

Cork compositions. There is an Armstrong Cork Composition made to meet each of the classes under Federal Specification HH-C-576, as well as each of the grades under specification MIL-C-16090.

Synthetic rubber compounds. Armstrong manufactures highly specialized synthetic rubber compounds for certain highly critical applications. If you need an out-of-the-ordinary rubber compound, please discuss your problem with your Armstrong representative.

Armstrong's Gasket Materials

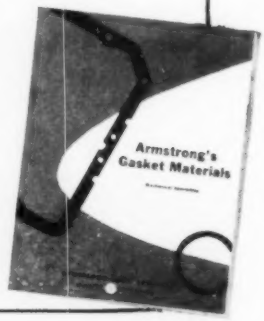
Send for this gasket manual

You'll find up-to-date information on current government specifications and tentative SAE-ASTM specifications in "Armstrong's Gasket Materials."

You'll find, too, in this 24-page manual, a lot of helpful information on the design and use of gaskets. Included are discussions of subjects such as designing gaskets to reduce cost . . . practical tolerances for resilient gaskets . . . designing flanges for efficient sealing, and many others.

See "Armstrong's Gasket Materials" in Sweet's file for product designers. For a personal copy of this manual, write to Armstrong Cork Company, Gaskets and Packings Dept., 7102 Arch St., Lancaster, Pa.

NEW REVISED EDITION



Your nearest Armstrong Industrial Division office

ALBANY 10, N. Y., 64 Northern Boulevard, Telephone: 4-0131 • BOSTON 16, Mass., 131 Clarendon Street, Telephone: COpley 7-2490 • CHICAGO 54, ILL., 13-136 Merchandise Mart, Telephone: DElaware 7-0500 • CINCINNATI 2, OHIO, Temple Bar Building, 138 E. Court Street, Telephone: PArkway 3220 • CLEVELAND 15, OHIO, 209 Hanna Bldg. Annex, Prospect Ave. and E. 14th Street, Telephone: MAin 1-7900 • DETROIT 26, MICH., 10th Floor, Free Press Building, 321 Lafayette Avenue, West, Telephone: WOodward 3-5670 • GREENVILLE, S. C., 33 Norwood Place, Telephone: Greenville 3-5302 • LOS ANGELES 15, CALIF., 719 Bendix Building, 1206 Maple Avenue, Telephone: RICHmond 0286 • NEW YORK 16., N. Y., 295 Fifth Avenue, Telephone: MUrray Hill 4-6900 • PHILADELPHIA 2, PA., Robinson Building, Fifteenth and Chestnut Streets, Telephone: LOcust 4-4290 • ST. LOUIS 3, MO., 1205 Olive Street, Telephone: CHestnut 1757 • IN CANADA: Armstrong Cork Canada Limited, 6911 Decarie Boulevard, Montreal, Quebec, Telephone: ATlantic 4733.

Materials ~ AVAILABILITY AND TRENDS

WILSON'S REPORT GLOOMY

Chief mobilizer Charles Wilson's fourth quarterly report to Truman takes a gloomier view of materials than its fore-runners. He finally surrendered the hope of a general easing of supply late this year. Now he says the pinch will extend into 1953.

Military goods already on order are expected to require more materials than previously estimated. The shortages he now forsees are based on known production schedules. If Congress votes a bigger Air-Force -- and it looks now as though it might -- the new production would be tacked on the end of existing schedules. That would mean another extension of shortages. This explains why Wilson gave up trying to predict when shortages will end.

The new Wilson line doesn't necessarily mean an end to such trends as more sheet and strip steel. This will continue, unless we trade ingots to Great Britain for aluminum or tin. Cold rolled strip is in group III of Defense Production Administration's list of basic materials. That means "fair to good supply". Hot rolled strip, and sheet, except galvanized, are in group II, which means "balance with essential demand". Even the acute shortage of plate may ease before mid-year. The plentiful supply of straight chrome stainless steel will continue.

ALUMINUM A DISAPPOINTMENT

Biggest disappointment is aluminum. Producers have 400,000 tons of new capacity coming in this year. That's a 45 percent increase over current output. The military will take most of it. The remainder will go to essential industries using it as a substitute for copper. There is sufficient plate rolling capacity to fill military needs, but rod and bar stock facilities are inadequate. Forgings are likely to run behind demand before the year is over.

COPPER PINCH

There will be some additional copper produced this year from domestic ores -- 72,000 tons more than last year, mobilizers estimate. But military demand jumped 28,000 tons for the second quarter alone. The world price has weakened some, but not enough to encourage forecasts of a ready supply at U.S. ceilings. The outlook is for continued shortages. Allocaters maintain the copper pinch will last at least five years. Copper producers challenge this idea. They want the government to stop encouraging the substitution of aluminum for copper, on the grounds that by 1956 their metal will be plentiful.

OTHER METALS

The growing shortage of tin is forcing the government to revise its price policy. Only 2,100 tons of new tin per month are going to industry this quarter, compared to normal consumption of about 5,300 tons. Even this supply is drying up. There have been no substantial imports allowed by the government since March, due to the refusal of W. Stuart Symington, former head of RFC, to pay more than $1.12 per lb. to foreign producers. Symington's resignation will be followed by some kind of a deal with producers, at something higher than $1.12. The impact on supply, however, may be only to sustain use at present levels, rather than allowing any increased use.

Magnesium output from the six government-owned plants is expected

(continued on page 115)

for

Exacting

CYLINDER CONTROL

¼" UNITITE JR. VALVES

Hanna ¼" Valves control air, oil or water pressures up to 500 p.s.i. The control lever requires only 80° movement for reversal. Hanna ¼" Valves are 4-way but can be made 3-way, by plugging one port. Three models—column, standard and manifold mount—are available. Ideal for tubing and light piping.

ELECTRIC VALVES

The Hanna 4-way Solenoid Valve is small, compact, with low current consumption. It is adaptable to straight line piping—capacity is equal to rated pipe size. Of balanced spool type, it has a built-in solenoid pilot valve. Piping may be from bottom, sides or a combination. Available in ⅜", ½", ¾" and 1" pipe sizes.

Hanna® valves

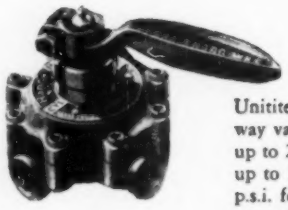
CHOOSE FROM a broad selection of Hanna Valves to meet your requirements for exacting Air and Hydraulic control. Illustrated are but a few of the complete line of hand, foot, electric and pilot operated valves for directional and speed control. They all carry the Hanna nameplate—an assurance of extraordinary care in design and manufacture—which means years of maintenance-free operation. Your Hanna sales representative offers specialized experience in selecting valve combinations and developing control circuits.

Send for Catalog

Hanna Valve Catalog No. 254 includes descriptions and specifications on the complete line.

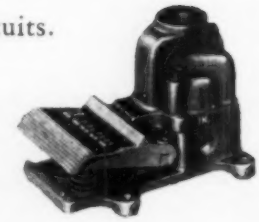
SPEED CONTROL VALVES

Hanna Flo-Set Valves have micrometer graduations to assure exacting speed control. Available in ¼", ⅜", and ½" sizes, they are suitable for air, oil or water control, with maximum pressure to 250 p.s.i. They may be mounted in any position.



UNITITE VALVES

Unitite Valves are suitable as either 3-way or 4-way valves, operating at air, oil or water pressures up to 250 p.s.i. for the ⅜", ½", and ¾" sizes . . . up to 150 p.s.i. for the 1" size . . . and up to 100 p.s.i. for the 1¼" size. Three styles—for standard mounting, column mounting or manifold mounting—are available.



FOOT OPERATED VALVES

Available in ⅜", ½", ¾" and 1" pipe sizes, Hanna Foot Valves are ideal for applications where it is desirable to have the operator's hands free for handling material. Single-pedal and double-pedal models, for pressures up to 250 p.s.i., are available for use with double-acting air and hydraulic cylinders.

Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES . . . RIVETERS

1763 Elston Avenue, Chicago 22, Illinois

to double this year. It will go mostly for military aircraft and stockpile, especially the light gauge. There will be some heavy gauge available for civilian uses.

Additional rules against the use of lead are certain if imports don't increase. The world price has come down close to the U.S. ceiling. If it stays there, imports can fill a gap made by increasing defense needs. Otherwise, expect another round of restrictions.

More zinc is expected from domestic mines this year, with some easing by April. There won't be enough to catch up with demand.

FOREIGN ELECTRONIC SUPPLIES

A number of critical electronic components in short supply in this country are available from foreign electronic manufacturers, according to a Defense Production Administration report based on a survey of German and Italian manufacturers. Items investigated were precision wire wound resistors, both fixed and variable; fine enameled wire; high accuracy deposited carbon resistors; and selenium rectifiers. The only items considered were those capable of production with existing facilities and available raw materials.

Seven of the twelve firms included in the report are located in Western Germany and the remainder in Milana, Italy. These companies were recommended to U.S. contractors in cases where delivery schedules of American-made components are slowing up the defense electronics program. Other items than the ones contained in this report will be investigated by government officials as limited quantities threaten to bottleneck production.

Deliveries of most items will run on an average of four to six weeks after the order is placed. Unofficially, it is estimated that the purchase price is approximately 30 to 50 percent less than equivalent components in this country, due, in part, to lower labor costs. This figure will be offset by air express and other charges.

SURVEY CONCLUSIONS

The survey team arrived at the following conclusions:

(1) Deposited carbon resistors with tolerances of 0.5, 1, 5, and 10 percent in values from 0.5 to 50 watts are available in quantity.

(2) At least one company has developed equipment for nearly automatic production of this type resistor.

(3) All companies produce a greater power range of resistors than the U.S. companies.

(4) Approximately 40 pounds per month of fine enameled resistance wire is available.

(5) Production of approximately half million selenium rectifiers per year is attainable.

(6) Appreciable quantities of precision wire wound resistors can be procured.

(7) At least two potentiometer manufacturers are capable of producing precision variable resistors in quantity.

In discussing the items investigated, the government officials noted a number of interesting facts.

In the deposited carbon resistor field, in general, sizes from 0.05 to 3 watt resistors were common production while some companies produced sizes to 50 watts. American production at present has been limited to sizes of from 0.5 to 2 watts. The small size resistor from 0.05 to 0.25 watt, the report stated, should be considered by the military departments for possible applications in electronic programs. One company has fastened the lead wires to the ceramic without the use of caps, which makes the resistors shorter in length by the size of the caps. Subminiature resistors were another interesting development.

"EYES AND DOLLS"

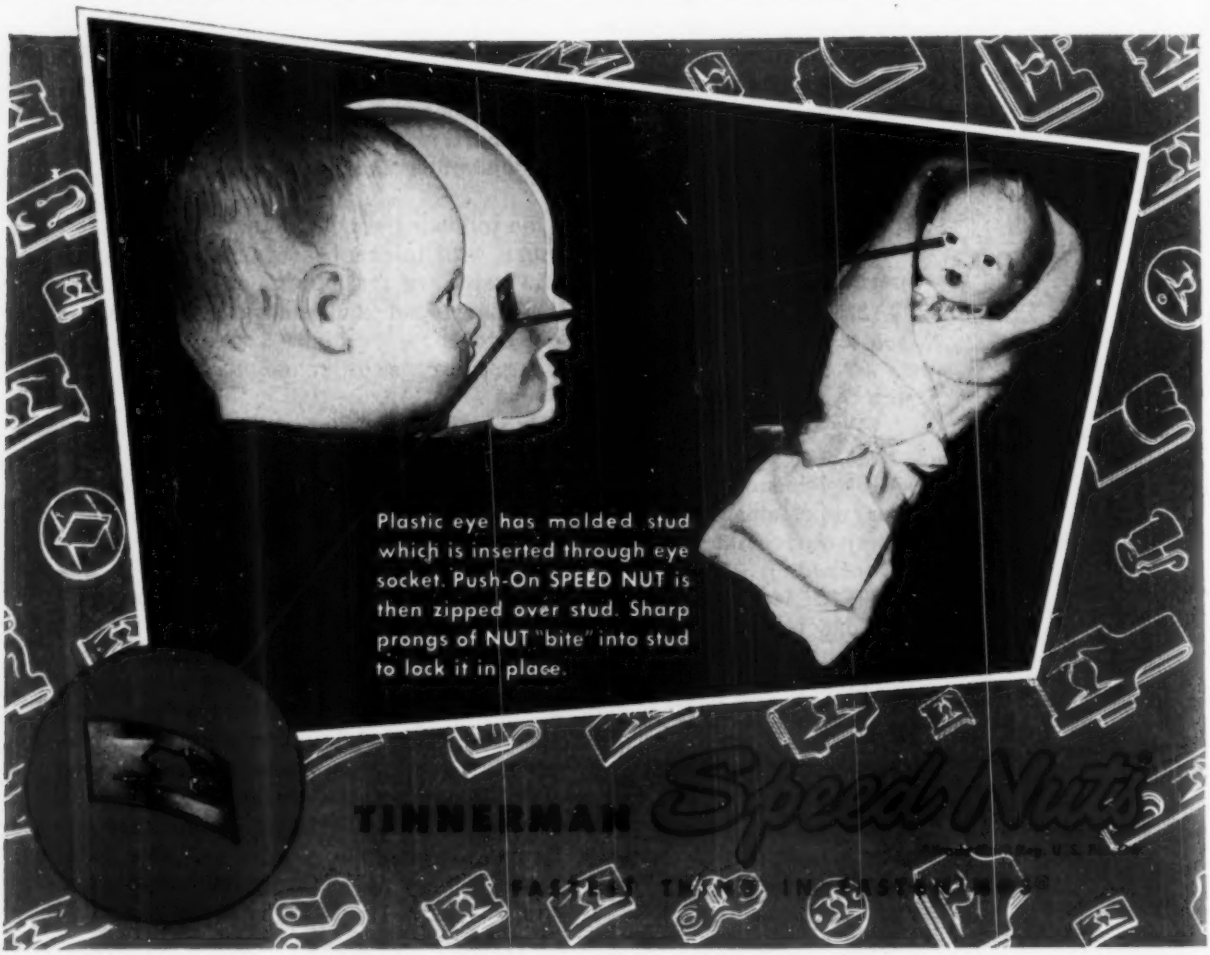
Plastic eyes held in doll's head with Push-On Type SPEED NUTS lead to 40% assembly savings

To please today's pigtail set, Goldberger Doll Mfg. Co., Inc., Brooklyn, N. Y., manufacturers of the EEGEE Doll, has made their newest baby doll unbelievably realistic. Every detail from the soft vinyl "skin" to the life-like plastic eyes does much to create the desired effect.

Attaching the eyes to the doll's head was a problem. Goldberger engineers first tried gluing them in place. This proved insecure when the head was compressed. Previous experience with Tinnerman fasteners led them to try Push-On Type SPEEDNUTS. They proved to be the perfect answer.

Furthermore, SPEED NUTS saved many assembly hours and dollars. *Despite an increase in material cost over the glue method,* SPEED NUTS *provided a net savings of 40% in assembly costs!*

If you are interested in further reduction of costs, we suggest that you check with Tinnerman. Call in your SPEED NUT representative soon. Meanwhile, write for your copy of SPEED NUT Savings Stories. TINNERMAN PRODUCTS, INC., Dept. 12, Box 6688, Cleveland 1, Ohio. *In Canada:* Dominion Fasteners, Ltd., Hamilton. *In Great Britain:* Simmonds Aerocessories, Ltd., Treforest, Wales. *In France:* Aerocessoires Simmonds, S. A.—7 rue Henri Barbusse, Levallois (Seine) France.


Plastic eye has molded stud which is inserted through eye socket. Push-On SPEED NUT is then zipped over stud. Sharp prongs of NUT "bite" into stud to lock it in place.
TINNERMAN
Speed Nut

You Can't Do Something for Nothing

SOME PEOPLE are terribly afraid of not getting credit for what they do. That is bad. Too often the fear becomes a phobia. Finally the victim avoids doing outstanding jobs because he is convinced some one else will get the credit.

Ironically, it is almost impossible to do a noteworthy job without getting credit for it. Do enough such jobs and the credit will be in the form of promotion, higher salary and the plaudits of associates.

There are many instances in which an affable fast talking individual stole credit from a meek hard worker. When that happens, what is the score? If the true creator of the accomplishment does not permit himself to grow bitter and full of hate, he will gain tremendously. Though they go to another, the plaudits will build his self confidence. He who should have received the credit will grow in character, stature and personality. Soon his creative ability becomes too obvious not to be recognized.

Rarely is it possible for a man to hide his abilities and accomplishments. Likewise, it is practically impossible for an individual to perform a service without being rewarded. The pay might not be in the coin of the realm; usually it is that and something of far greater value.

To help an acquaintance who was in a tight spot, an engineer solved a vexing problem for him. He did it without pay; he didn't expect any. Two years later he was offered out of the blue sky a highly responsible and lucrative position. The acquaintance whom he had helped had recommended him. The job he had done had convinced the prospective employer of the man's abilities.

He who steals another's credit is setting the stage for his own downfall. Sooner or later he is called upon to deliver on his own. He fails.

When another lays claim to one's accomplishment, it is not fitting to bluster and protest like a child. More effective is it to retain poise and dignity and set forth claims with the calm assurance that justice will prevail eventually.

Even though the cards be stacked and the deal is lost, there is always the next deal coming. Soon there are others who recognize the doer and his accomplishments. Because injustice is hated, these "witnesses" become vocal and the wrongs are righted.

The other aspect of credit is the lack of interest some men have in their job because, "It doesn't amount to much." The answer to that is simple and brief. Every job is important—for the want of a nail the battle was lost and the empire vanished. Secondly, the most profitable way to get rid of a distasteful job it to get promoted out of it. And the way to do that is to get credit for a job well done. He who takes good care of little details becomes the supervisor over big jobs.

G. F. Rodenholt

It's no time to guess—about Quality
Cling to the tried and true, in Ball Bearings too. New Departure not only makes them of unsurpassed quality but builds in predictable performance under known conditions. Consult a New Departure engineer while your design is in the blueprint stage.
Nothing Rolls Like a Ball...
NEW DEPARTURE
BALL BEARINGS
NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT

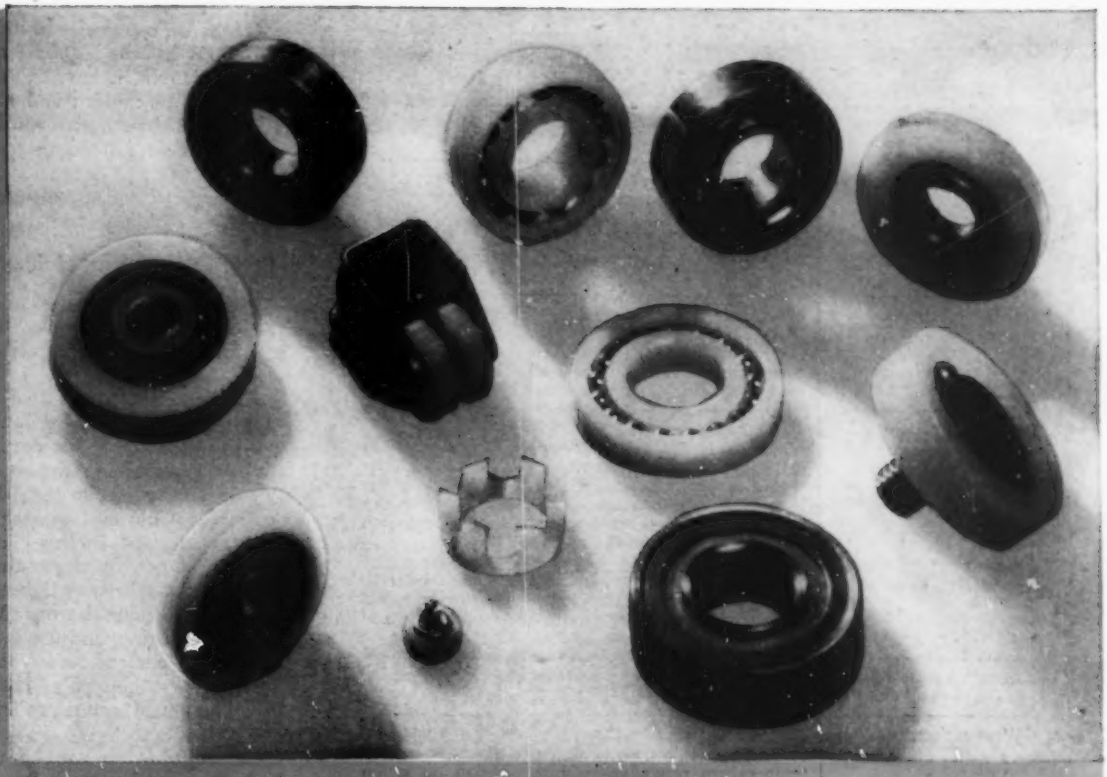


Fig. 1—Ball bearings with molded and stamped nylon components. The molded races or treads are practical for lightly loaded, slow speed bearings, but nylon seals may supplant rubber in precision pre-lubricated bearings. In the latter application, leakage and friction are low.

Now: Nylon Parts for Ball Bearings

F. W. RECKNAGEL
Chief Engineer,
The Schatz Manufacturing Company

NYLON IS INHERENTLY WELL SUITED as a bearing material because of its (1) excellent resistance to corrosion and wear; (2) low coefficient of friction; and (3) adaptability to various lubricating conditions and fluids. Equally important, it has good shock resistance and noise deadening characteristics, and today is in better supply than many of the steels, brasses, bronzes, and other alloys that are commonly used for bearings.

While the combination of the qualities in any material seemingly would justify its use for both sleeve and ball bearings, nylon up to now has been limited to sleeve bearing applications and to small mechanical parts such as cams and gears (see PRODUCT ENGINEERING, July 1950). However, in the past several months, development work in both the laboratory and the field has proven the value of molded, stamped, and machined nylon ball bearing components.

The salient reasons for turning to plastic are noise reduction and resistance to corrosion. Steel balls rolling on plastic races are quieter than steel balls on steel races, even if only one race is made of plastic. Such bearings immediately find application in business machines, household appliances, automobiles, and other products where quietness of operation is essential. Ball bearing rollers for doors and drawers also are quieter when plastic races or treads are used.

High resistance to corrosion opens up other fields of use, particularly in the chemical industry

Table I—Properties of Molded Nylon Bearing Parts

Property	Values
Mechanical strength	*Tensile:* 15,700 psi at—70 F; 10,900 psi at 77 F; 7,600 psi at 170 F. *Shear:* 9,600 psi *Flexural:* 14,600 psi at 77 F. *Impact:* 0.4 ft-lb/in. Izod at—40 F; 1.5 ft.lb/in. at 77 F.
Other mechanical properties	*Elongation:* 1.6 percent at—70 F; 50 percent at 77 F; 320 percent at 170 F. *Hardness:* R118 Rockwell. *Compressive stress:* 4,900 psi at 1% deformation. *Deformation:* 1.4 percent at 122 F and 2,000 psi.
Thermal properties	*Flow Temperature:* >480 F *Heat distortion temperature:* 170 F under 264 psi; and 400 F under 66 psi Nylon is more sensitive to dry heat than to moist heat, and continuous exposure above 250 F in dry heat may cause embrittlement. Water absorption is 1.5 percent by ASTM method D570–42.
Chemical resistance	Insolvable to most organic solvents and inert to alkalies. Resistant to food acids, lactic acids, photographic solutions, and to petroleum oils and greases at temperatures up to 325 F.
Abrasion reistance	Nylon has a tendency to completely curb abrasive particles such as dust and dirt.
Wear resistance	Shows little wear in thermally stable applications, and has approximately same load carry capacity and temperature range as babbitt. Nylon on nylon shows lowest wear, nylon on steel is almost as good, and nylon on brass or bronze shows highest wear.
Lubrication	Can be lubricated with oil, or such fluids as gasoline or solvents. Can also be run dry but break in period is critical if bearings are run near maximum load capacity. High grade motor oil is best lubricant, but other fluids can be used satisfactorily.

(1) Type FM 10001 nylon.

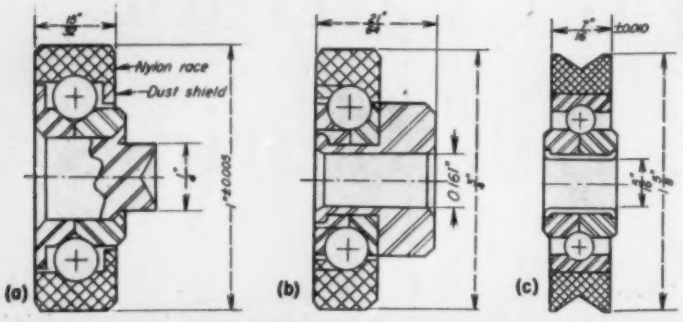


Fig. 2—(a) Commercial ball bearing with molded nylon outer race and integrally molded dust shield. (b) Another type of bearing with nylon outer race; (c) integral pulley and bearing with nylon tread instead of steel.

where corrosive fluids and vapors necessitated stainless steel components. Typical are pump bearings for the petroleum industry, high speed bearings for aircraft where exhaust gases are involved, and bearings for photographic process equipment that is immersed in water or in hypo tanks. Substituting plastic for certain parts of such bearings in many cases results in improved performance at lower cost.

There are, of course, several plastics that might be used, but only two with the required tensile strength and resistance to impact: nylon and teflon. Teflon has most of the desired characteristics, but is somewhat more difficult to mold and much higher in cost.

Of the various grades of nylon, type FM-10001 has the highest tensile and impact strength, is lowest in cost, and can readily be molded and machined. Table 1. Although the powder must be dried before molding to prevent embrittlement, the dimensional change of the material due to moisture absorption after molding is small.

Ball Bearings With Molded Nylon Parts

Molded parts used successfully in ball bearing applications include inner races, outer races, and ball cages. Stamped sheet has been used for seals on prelubricated precision bearings, as will later be discussed in detail.

Generally speaking, the use of nylon as ball bearing race material has been confined to low cost bearings of the commercial class. In this class, tolerances are somewhat greater than established for precision ball bearings by the Anti-Friction Bearing Manufacturers Association, and use is confined to lower speeds and loads—the values depending on the type of bearing, the ball compliment, and the tolerance and materials.

Although nylon can be used for both inner and outer races, there is a disadvantage in doing so. Commercial type bearings are frequently assembled by riveting or are held together with a stud, and since nylon is subject to cold flow, more care must be used during the assembly operation to obtain the exact degree of looseness. Otherwise the bearing will become tight.

For this reason, the inner race is made of low carbon steel unless service conditions are corrosive and stainless steel would otherwise be required, as for example, a bearing for an aircraft fuel pump. A typical bearing in which the outer race is molded of nylon is shown in Fig. 2(a). This is a roller application, the bearing being used as a treaded roller in a sliding door. A feature of the race is a dust shield that is integrally molded with it.

In the bearing illustrated in Fig. 2(b), a different method of assembly is employed, while in the unit, Fig. 2(c), nylon is used for the treaded roller, which serves as a guide roller for bale wire and is used in hay balers. This application is one that requires a material having excellent resistance to abrasion. Nylon has lasted longer than materials previously used.

It will be noted that the above bearings are for low speed, lightly loaded use. As yet there is no actual data on the loads and speeds at which nylon races can be used, but indications are that speed is as critical as load. At high

speeds, nylon cold flows due to the speed of the balls, and a speed of 2,000 rpm is too high at the present time. On a bearing having both inner and outer races molded of nylon, a safe load would be on the order of 15 percent of that used for hardened steel at a speed of 750 rpm. For more accurate data, this bearing should be subjected to load-life tests under actual service conditions.

If bearings are stationary under load for some period of time, the balls will make depressions in the race, but this is not a permanent brinell. These depressions work out after a short period of service. On one bearing used for a dishwasher roller, the total load is 100 lb per bearing, and no trouble is encountered due to brinnelling.

For a bearing with a molded outer race, the maximum operating temperature limits are between 200 and 250F. Above these temperatures, the material loses sufficient hardness to affect performance.

Insofar as size is concerned, nylon imposes no limitation, although its coefficient of expansion may be a limiting factor in certain applications where high heat is involved. Above about a 4 in. dia and a 1.0 in. thick blank, porosity becomes a problem, but a piece of this size is beyond the requirements of the bearing industry. The largest bearing made to date with a molded nylon race is 1½ in. in diameter.

Nylon Grease Seals

More test data has been obtained on nylon grease seals than on the previously described bearing applications. Comparative tests on nylon, Fairprene and Buna N rubber and felt seals have shown that nylon is preferable for the following reasons:

1. Less grease loss
2. Lower operating temperatures
3. Lower torque
4. Lower costs

Data from tests that were run to compare grease loss and seal endurance are given in Tables II to IV. In Table II, which summarizes the results of high-speed no-load operation, only one run was made with Andox C grease with a nylon seal, and comparison with the test with a Buna N seal and the same lubricant shows the nylon to be inferior. However, assuming that the type has no effect on the seal performance, the average loss from the nylon sealed bearings was 0.0339 gm compared to 0.3727 gm with a Fairprene seal and 0.1562 gm with a Buna N seal.

In other tests under radial, thrust, and eccentric loads (see tables) no direct comparisons were obtained except with a felt seal and a steel cage, in which case the nylon seal proved superior.

During these tests, it was noticed that there was a reduction in initial operating temperatures when nylon seals are used as compared with Fairprene or Buna N rubber. This is probably caused by the lower coefficient of friction of the nylon materials. These operating temperatures are obtained by using automatic temperature recorders with the thermo-couple in contact with the bearing outer ring. In Fig. 3 are charts that illustrate the variations in temperature for bearings having different seal construction.

Finally, the lower coefficient of friction of the nylon material, with

Table II—Comparative Efficiency of Bearing Sealing Materials at High Operating Speeds (1)

Type of Seal	Type of Grease	Grease loss, gm	Temperature, F	
			Maximum	Running
Nylon	M-24	0.0498	233	130
Nylon	M-24	0.0262	225	160
Nylon	M-24	0.0246	225	150
Nylon	M-24	0.0445	205	130
Nylon	Andox C	0.0330	170	150
Nylon	M-24	0.0447	220	145
Nylon	M-24	0.0171	160	140
Nylon	M-24	0.0275	180	165
Fairprene	M-24	0.3563	300	180
Fairprene	M-24	0.3868	...	...
Fairprene	M-24	0.3751	235	130
Buna-N	Andox C	0.0246	...	...
Buna-N	Andox C	0.5082	...	...
Buna-N	Andox C	0.0280	...	...
Buna-N	Andox C	0.0636	275	275

(1) All bearings operated at 19,000 rpm for 6 hr, no load. Temperatures measured with automatic recorders.

Table III—Endurance of Nylon Seals Under Load (1)

Length of test, hr	Type of grease	Grease loss, gm	Condition of	
			Seal	Bearing
67	ANG-25	0.0322	Excellent	Excellent
67	ANG-25	0.0059	Excellent	Excellent
578 1/2	ANG-25	0.1391	Excellent	Excellent
578 1/2	ANG-25	0.0498	Excellent	Excellent
558	M-24	0.005	Excellent	Excellent
558	M-24	0.0105	Excellent	Excellent
214 1/2	M-24	0.0097	Excellent	Excellent

(1) Test load: 350 lb radial, 180 lb thrust. Operating speed: 500 rpm.

Table IV—Efficiency of Nylon Seals Under Eccentric Loads (1)

Seal	Cage	Grease	Temperature, F		Length of test, hr	Grease loss
			Maximum	Running		
Nylon	Nylon	S-58	270	270	241	0.3645
Nylon	Nylon	S-58	260	260	47	0.500
Nylon	Nylon	S-58	260	260	24	0.370
Felt	Steel	S-58	270	270	24	2.52
Felt	Steel	S-58	290	290	24	1.54
Felt	Steel	S-58	260	260	24	0.32
Felt	Steel	S-58	300	250	24	1.85

(2) Eccentric load of 1/2 oz to 1.0 in. Operating speed: 4,900 rpm.

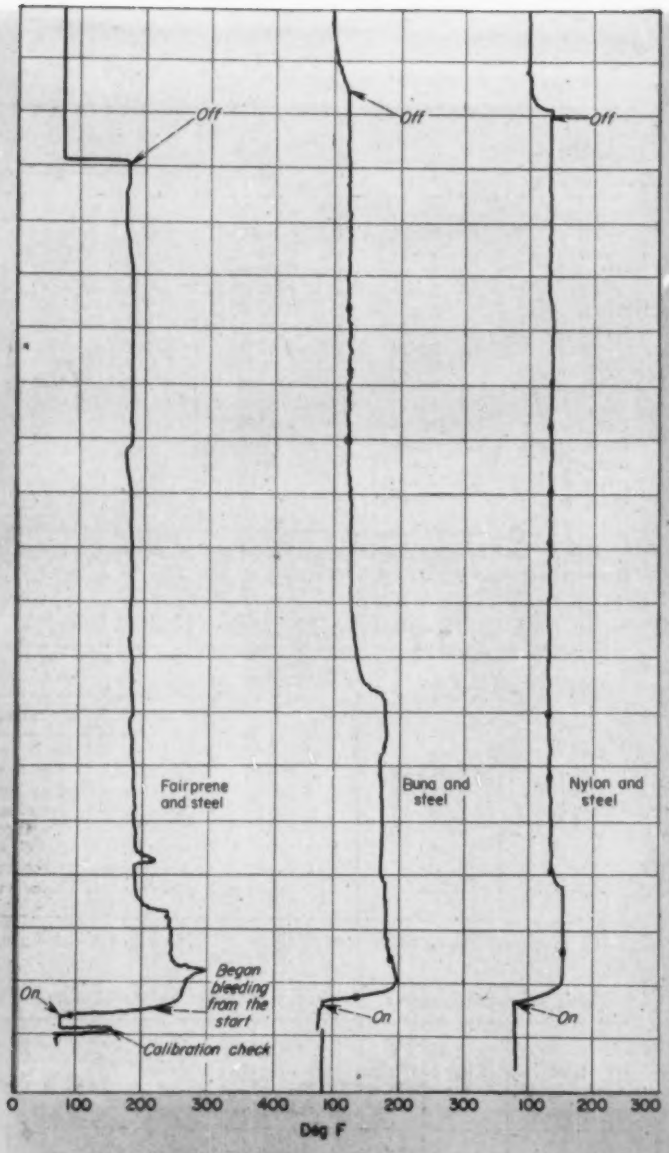


Fig. 3—Comparison of operating temperatures of bearings with nylon, Fairprene, and Buna N rubber seals. The bearings were run for 6 hr at 19,000 rpm. Grease loss from the nylon sealed unit was 0.0174 gm as compared to 0.3563 gm and 0.508 gm for Fairprene and Buna N respectively.

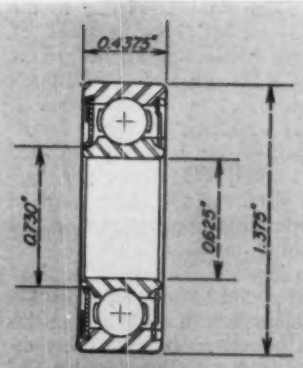


Fig. 4—How nylon seals are used. This is a ground bearing that serves as a lawn mower reel support.

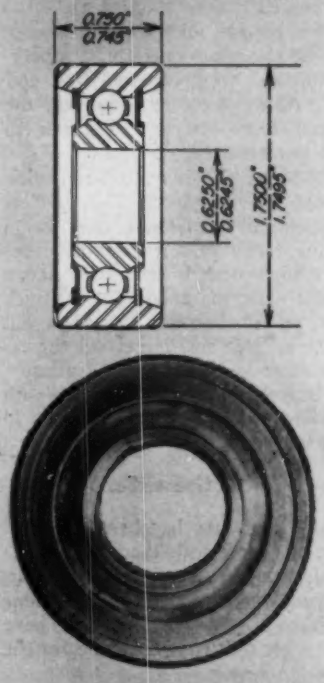


Fig. 5—A double nylon seal is used on this bearing for an idler pulley, whereas only one side of the bearing in the Fig. 14 is sealed.

the attendant lower operating temperatures, has a noticeable affect on bearing torque. And last but of considerable importance, nylon, whether molded or in strip form, is relatively inexpensive and compares favorably with the cost of other sealing materials.

Examples of bearings having nylon seals are the two, Figs., 4 and 5, used in power lawn mowers. The bearing shown in Fig. 4 is a ground bearing that serves as a support for the reel of the power lawn mower. Nylon is used as a seal material on one side of the bearing. It serves as a contact seal to prevent the entrance of dirt and the loss of grease.

The unit shown in Fig. 5 is also a power lawn mower application, but in this case the bearing is used as a belt idler pully. It is essential here that a close fitting, efficient seal be employed to prevent the entrance of dirt and dust. This bearing is sealed on both sides.

In most cases these nylon seals are blanked and pierced from strip using ordinary blank and pierce dies with minimum punch clearance. Generally, nylon strip of from 0.010 to 0.020 in. thickness is used, depending upon the diameter of the bearing to be sealed. When assembled, these nylon seals are depressed into a groove and are retained in position by a flat steel shield. The only purpose of this steel shield is to fix the seal in permanent position in the bearing outer ring groove. The inner diameter of the nylon seal rides in contact with a curved seat on the inner bearing ring or cone. The location of this radius on the inner ring

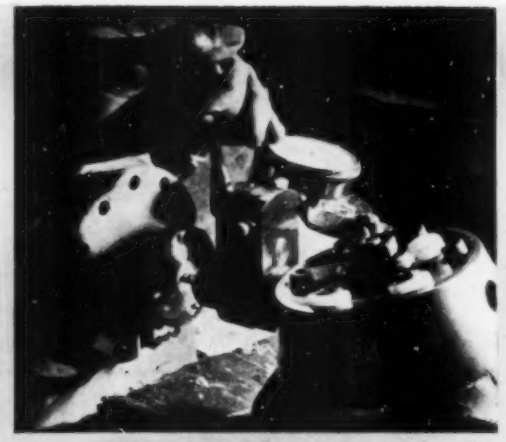


Fig. 6—Machining nylon. Ball race on the outer ring is turned with a special tool from molded nylon stock. This operation is performed on a screw machine.

Fig. 7—Checking the quietness of a bearing under running conditions with an Anderometer. This machine translates radial deviation into an electrical measure.

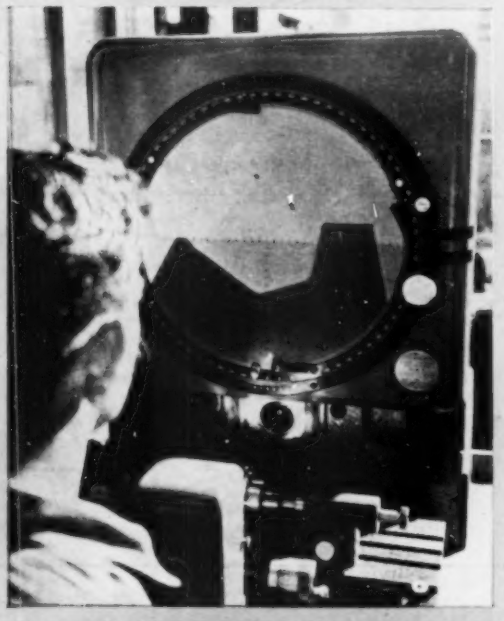


Fig. 8—A Kodak comparator used to check contour of a form tool; absolute accuracy in tools is required. After being machined, the bearing races are ground.

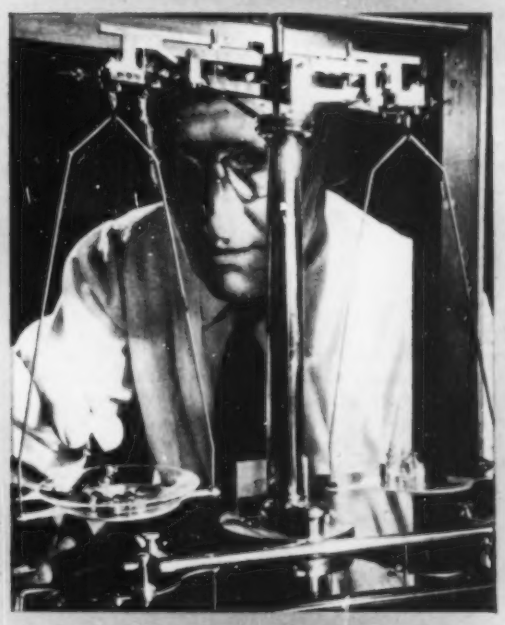


Fig. 9—Checking grease loss after an endurance test is done by weighing bearings on a balance before and after test. See text for nylon sealing characteristics.

is important since it is located in such a position that a certain amount of seal flexure is obtained to provide a permanent running contact of the seal inner diameter with the bearing inner ring. Details of various constructions are illustrated in Figs 4 and 5.

In another application, a molded nylon seal is used. This is only done in cases where it is necessary to seal a shaft, and in such cases a curved lip must be molded on the seal bore to provide adequate sealing contact with the shaft. The same type of steel shield is used to fix securely the nylon seal in the outer ring groove.

Expanded Use of Nylon Bearings Certain

These preliminary applications of molded and stamped parts have shown that nylon has excellent possibilities as a supplemental material for ball bearing races, particularly where quietness of operation and high resistance to corrosion are important. However, much development work still is required before design limits for such bearings can be established and also before the possibilities of molded nylon ball cages can be fully explored. Nylon shows considerable promise for this latter use, but there are certain applications for which it does not give complete satisfaction.

For ball bearing seals there is not much doubt that nylon will supplant rubber in many cases. All the data obtained to date indicates that it is superior to the commonly used sealing materials and that its adoption will result in improved operation.

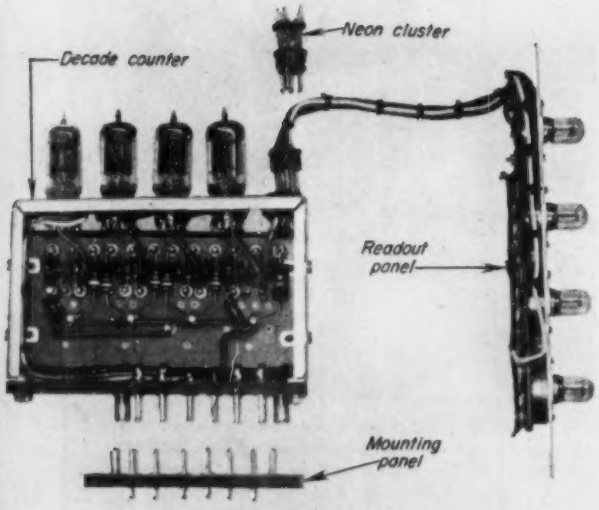


Fig 1—Typical plug-in counter decade having four tubes and remote readout panel. Small neon cluster locates defective tubes where complete readout is unnecessary. In this form, the counter is suitable for installation as an integral part of a complete product or machine. The counter can be supplied also as a separate electronic assembly.

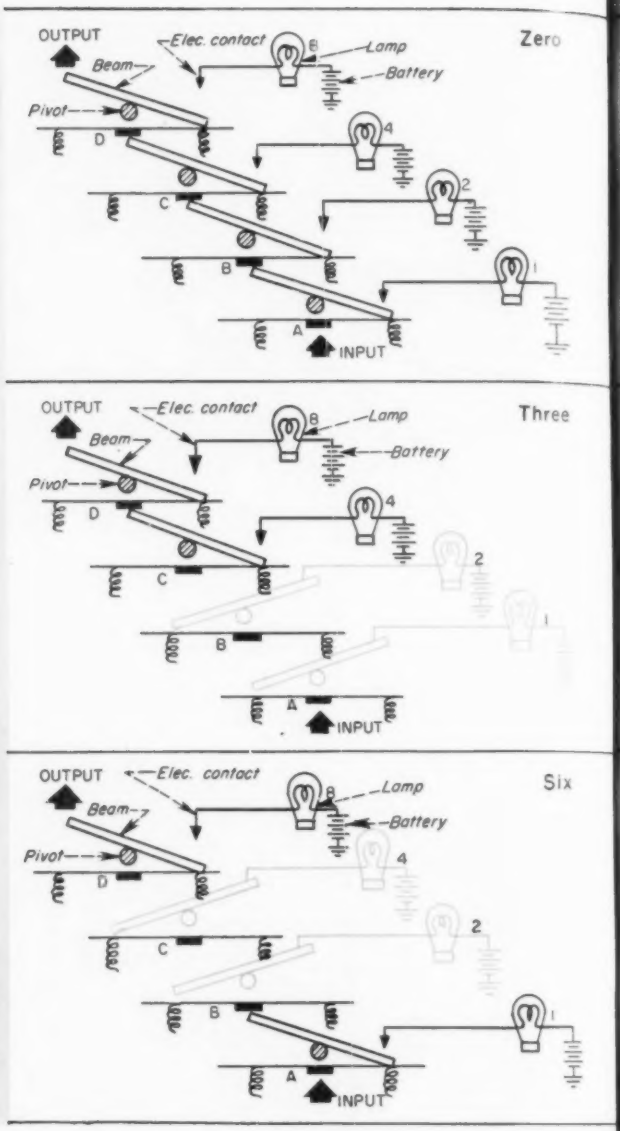


Fig. 2—Mechanical analogy of the flip-flop method of counting. Successive hammer blows at point A cause the beams to see-saw repeatedly. Lamps are lighted to indicate the number of blows imparted. Platforms under each lever are mounted on springs, which return the platforms to the neutral position after a blow is struck. It is assumed that the springs are critically damped by some means to prevent platforms from vibrating and upsetting the count.

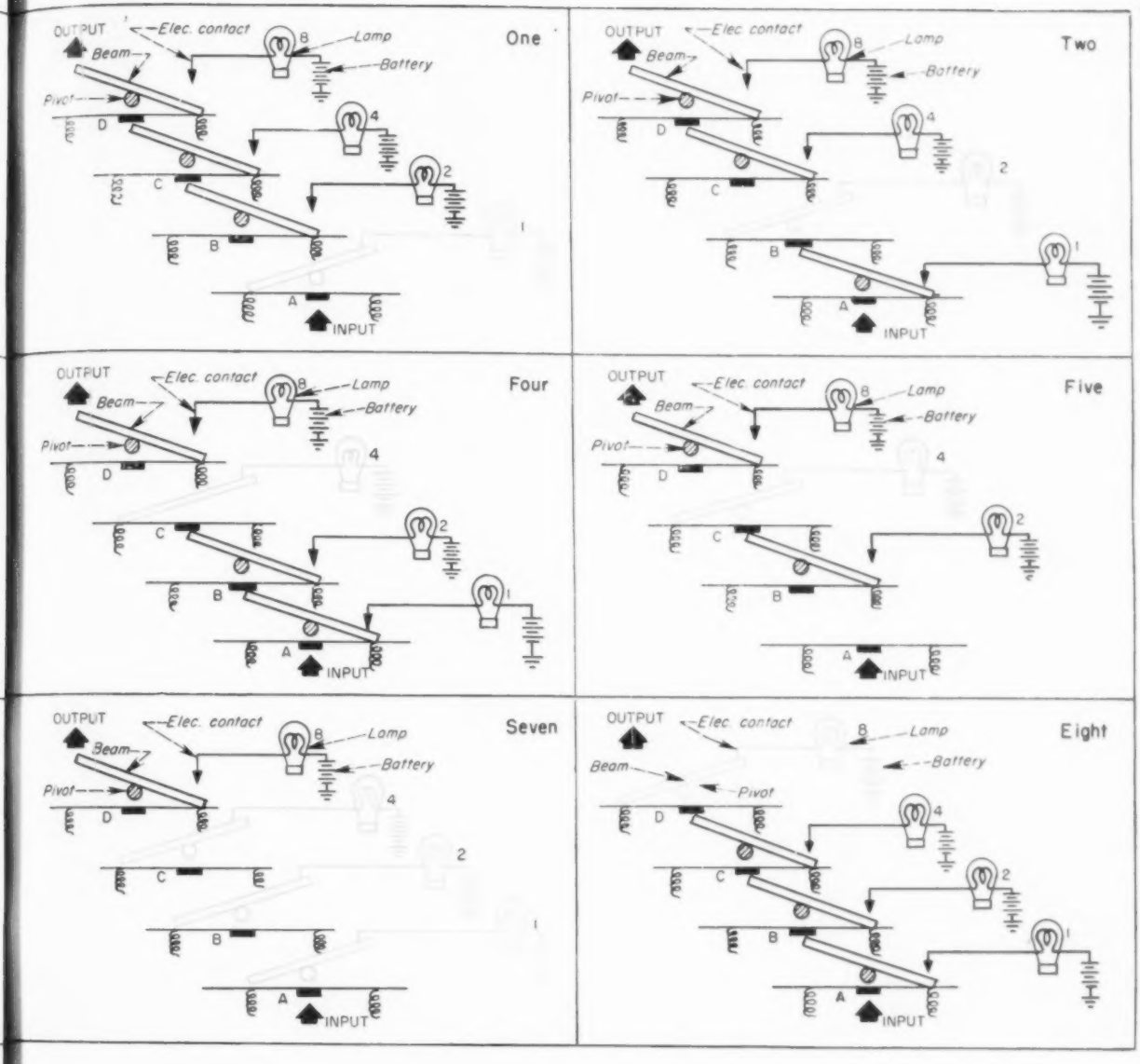
The Electronic Flip-Flop....

STATED BRIEFLY, electronic counters are fast and accurate. A counting rate of over a million digits per second is well within the capacity of this type of device, and, despite this performance, the counter is simple in design and construction. That this combination of speed and simplicity is of interest to product engineers is evidenced by an increasing number of machine applications.

One version of the electronic decade counter, Fig. 1, is a compact, plug-in unit consisting of four vacuum tubes connected to a network of capacitors and resistors. Decades are so named because they completely cycle in ten steps. A progressive circuit change takes place in the decade for each impulse received. After ten such changes, the decade generates an output pulse to drive the following decade or actuate a control. A chain of decades will thus successively count units, tens, hundreds and so on.

The decade is divided into four stages, each consisting of one tube and its associated components. Two stable conditions of operation are possible in any stage and a swing from one to the other happens instantaneously in response to pulses. Because each input pulse causes one or more of the stages to swing from one condition to another, the stages are termed electronic "flip-flop" circuits.

A continuous visual indication of the circuit conditions is given on a readout panel, which is a group of four neon lamps. The four lamps are numbered 1, 2, 4 and 8. The lamps are lighted, singly or in combination, to



as a machine element

JOHN B. FLYNN
Application Engineer
Potter Instrument Company, Inc.

show the total number of impulses impressed on the input terminals of the counter decade. For example, both the No. 1 and No. 2 lamps are illuminated when three electrical impulses are admitted to the counter. These readout panels can be calibrated to read directly in units such as feet, pounds or revolutions, depending on the application. Or, the readout panel may be dispensed with if a numerical indication is not required.

The simple and dependable flip-flop circuit used in the decade counter can probably be best made clear by a mechanical parallel. The accompanying sketches in Fig. 2, show four balanced beams whose equilibrium is upset by driving force exerted at Point *A*. All beams as shown in the first sketch may be regarded as in the off position. A below at Point *A*, tips the first beam to its opposite position. In the decade this would light lamp 1. A second blow again reverses the first beam which in turn imparts an impact at Point *B*, causing the second beam to swing over. In this process lamp 1 goes out, lamp 2 goes on. Every second blow at *A* affects *B* and in turn every fourth affects *C*, every eighth *D*. In this way the stages and coupled neon lamps acquire their respective values of 1, 2, 4 and 8.

Study of the sketches in Fig. 2 shows that if this symmetrical see-sawing were allowed to continue, all lamps would be lighted after the fifteenth blow. The sixteenth blow at point *A* sets up a chain reaction that returns all levers to their original position. But for convenience in count-

ing, an actual decade counter is designed so that at the tenth impulse a new circuit element is introduced which resets all stages to the zero condition. The last stage, in returning to its original condition, generates an output pulse. This pulse can be used to feed into another decade section, where counting of multi-digit numbers are involved, or to initiate a control action in a machine or process application.

The number of pulses which have entered the decade are indicated on the panel-mounted neon lamps which remain lighted when the count is completed. The diagram, Fig. 3, illustrates how the lamps, singly or in combination, exhibit a typical count. The five sets of lamps, each of which is controlled by a decade section, make possible counts as high as 99,999. Higher counts are effected by adding additional decade sections in cascade.

Electronic Circuit

In the electronic counter, each "flip-flop" beam is replaced by a tube and a so-called trigger circuit. As in the mechanical analogy, there are four stages in a counter decade. The tube used in the trigger circuit has within one glass envelope two separate triode elements. These are both interconnected as shown in Fig. 4 to a balanced network of resistors and capacitors. When the right hand section is conducting (as indicated by the shading), the neon lamp is out. When the left hand section is conducting, the neon lamp is lit for indication.

A power pack and voltage divider are used to apply voltages at appropriate points in each trigger circuit. These voltages are +300 v on the plate circuits of the tubes and +150 v on the cathodes. The other voltage values indicated on the diagram in Fig. 4 are established by *IR* drops in the various resistors.

Before arrival of the first pulse, assume that the grid of the right hand triode is at cathode potential so that there is zero bias on the grid. At zero bias, the right-hand triode will conduct saturation plate current, and its plate-cathode voltage drop will be low. For this assumed initial condition, then, the neon lamp in the stage is extinguished.

The grid bias voltages control the switch-over from one triode section to the other in a stage. These bias voltages are obtained from points a and b on the two branches of the resistance network.

This explanation will help to show why points a and b give different bias values. If the tube were removed, each branch of the resistance network would act simply as a bleeder across the power supply and voltages would divide in proportion to resistance values. Under this condition point a and point b would be essentially at cathode potential (+150 volts above ground).

With the right-hand triode section conducting, however, it draws current through resistor R_6 and greatly increases the voltage drop across R_6. This leaves less voltage for R_4 and R_2, and hence drives point b in a negative direction with respect to the cathode. A shift of 25 volts was found sufficient to drive a triode section to cutoff, and resistor values were accordingly chosen to give this distribution of voltages.

Referring to Fig. 4(a), note that the grid of the right-hand triode is connected to point a, which is at cathode potential, as assumed for this explanation and as required for saturation plate current in this section. The grid of the left-hand triode goes to point b, which is at +125 volts with respect to ground and hence 25 volts negative with respect to the cathode. This being essentially the cutoff bias, the left-hand triode is nonconducting under the initial assumed conditions.

The stage is stable in this condition until a negative pulse (with respect to ground) is applied to its input circuit. Any positive pulse fed into the stage has no effect, because it is dissipated in the low impedance of the conducting triode section.

Upon arrival of a negative pulse at the input, both grids swing in a negative direction, just as if a battery were connected across R with its positive terminal going to ground. There is no direct effect in the nonconducting left-hand triode since its grid is already at negative cut-off, but the negative grid swing of the right-hand triode stops its plate current. The resulting redistribution of voltage drops across R_6, R_4 and R_2 places point b at cathode potential as indicated in Fig. 4(b). Thus the grid of the left-hand triode swings positive to zero bias, and the left-hand triode conducts.

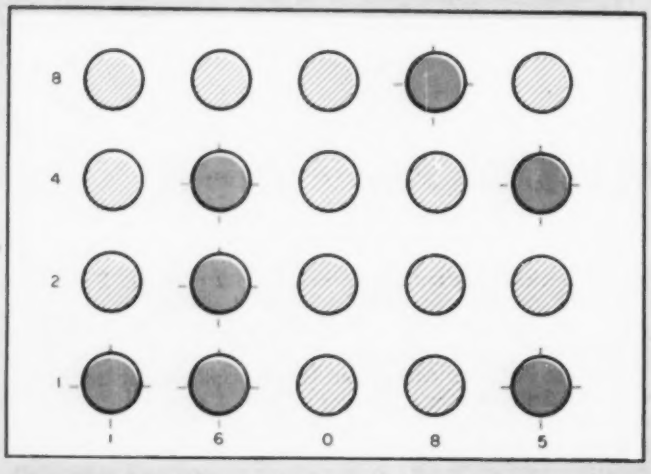


Fig 3—Lighted lamps give visual indication of count. Above panel has maximum capacity of 99,999 digits yet it is compact in size.

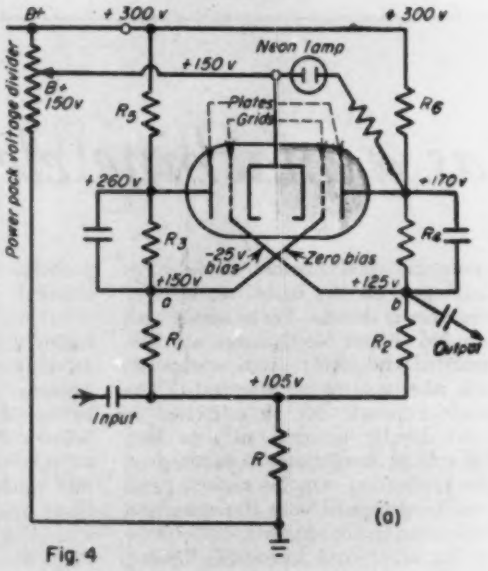


Fig. 4

Point a goes 25 volts negative with respect to the cathode, keeping the grid of the right-hand triode negative once it is driven negative by a negative input pulse. Thus, original circuit conditions with respect to right and left-hand triodes are reversed.

With the right-hand triode nonconducting, its plate-cathode voltage goes up to about 110 volts, above the striking value of the neon lamp, and the lamp glows.

Arrival of a second negative pulse again triggers the stage, returns it to the original conditions of Fig. 4(a), and extinguishes the neon lamp. Also, the swing in the potential of point b from the +150 v of Fig. 1(b) to the +125 v of Fig. 1(a) produces a negative pulse that is transmitted through the output capacitor of the stage to the input of the next stage.

It is seen from the above that electrical signals or impulses can be counted by means of the electronic decade device. The count is indicated visually. And, at the end of a count, the decade generates a signal impulse that can be used to trigger a control device.

In the majority of cases where a counting system is to be used for control purposes, ability to initiate action at predetermined points is demanded. The means of setting in a predetermined count should be simple. In high speed automatic operations the time required for returning to the starting point for re-cycling must be held to a minimum. If the system has a capacity for handling two or more count intervals in sequence, its utility is multiplied. The electronic counter meets all of these conditions.

Any predetermined count may be preset directly by injecting a suitable pulse at one side or the other of each decade stage. The most straight-forward method employs ordinary wafer switches, one for each decade, with dial settings of 0 to 9. By proper wiring interconnection to the various grids, the wafer switch channels the preset impulse forcing the desired "on" or "off" conditions to be assumed. The nature of the impulse is such that a stage already correctly positioned will not be upset.

An electronic decade counter generates the control pulse only at the end of a complete count. Thus, in a device of one million digit capacity, the signal is transmitted on arrival of the one millionth input pulse. But a counter can be set to generate the control signal after any given count that is less than maximum capacity. This can be done by means of the wafer switches mentioned. These switches actually preload the counter with the difference between the maximum capacity of the counter and the count required for the application.

To explain further, suppose that it is desired to use a 1,000 digit capacity device to signal after a count of only 250 units. The electronic circuits of the counter are preset by means of the switches so that on zero count these circuits are actually in the condition corresponding to the complementary value of 250 or 750. Since 750 is the starting count, the addition of 250 fills up the 1,000 digit counter and causes an output pulse to be transmitted. Only one initial presetting is required. At the end of each count of 250, the decade counter automatically resets itself to the 750 unit starting point.

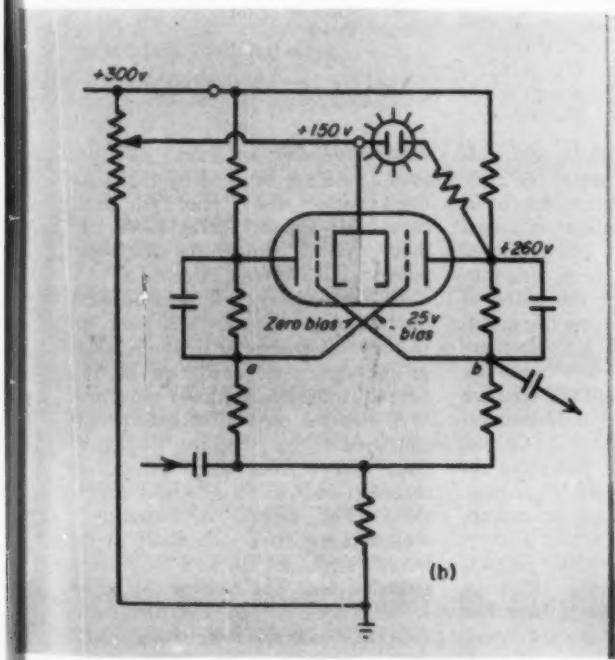
It is important to note that automatic presetting is completed before the next pulse arrives. No loss of count, no interruption in process is involved.

Additional groups of wafer switches permit selecting two or more predetermined counts. The three-sequence counter is designed to initiate a control action after each of three different predetermined counts. As each count in turn is completed, a switching device in the counter output selects the next group of wafer switches to channel the preset impulse, again without missing count or introducing a lag.

As a logical evolution, complete programming of processes can be achieved with predetermined counts derived from punched tapes, cards or disks. Carried to this point, the elec-

Fig 4—Basic circuit used in electronic decade counter. Two triode tubes are contained in single glass envelope. Counting pulse admitted to tube extinguishes one triode and causes the other to fire in a flip-flop fashion.

Fig 5—Packaging machine for handling small pieces, such as tacks and screws. Made by Special Machinery Company, the machine is controlled by an electronic counter which is tripped by impulse from photocell system.



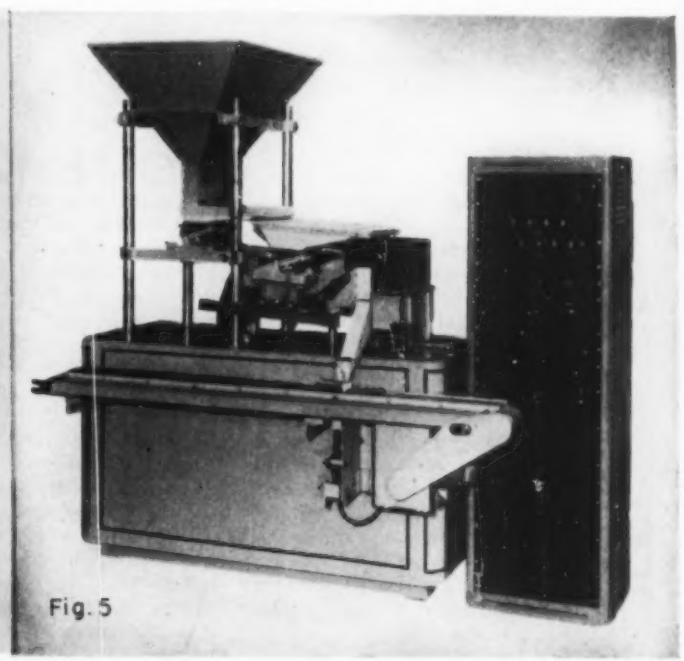


Fig. 5

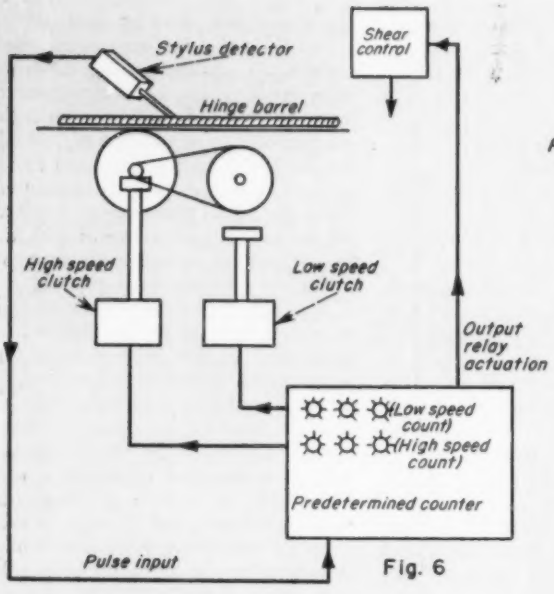


Fig. 6

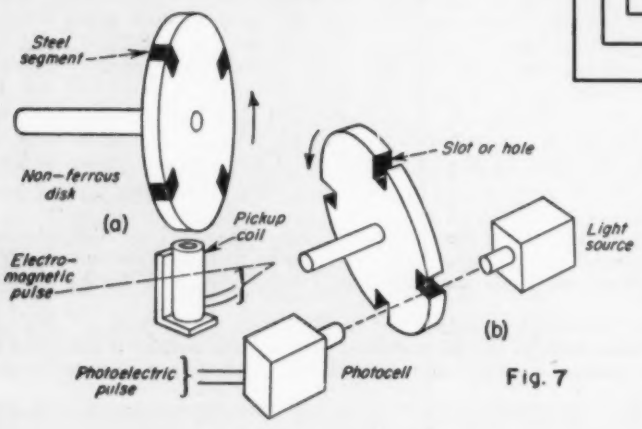


Fig. 7

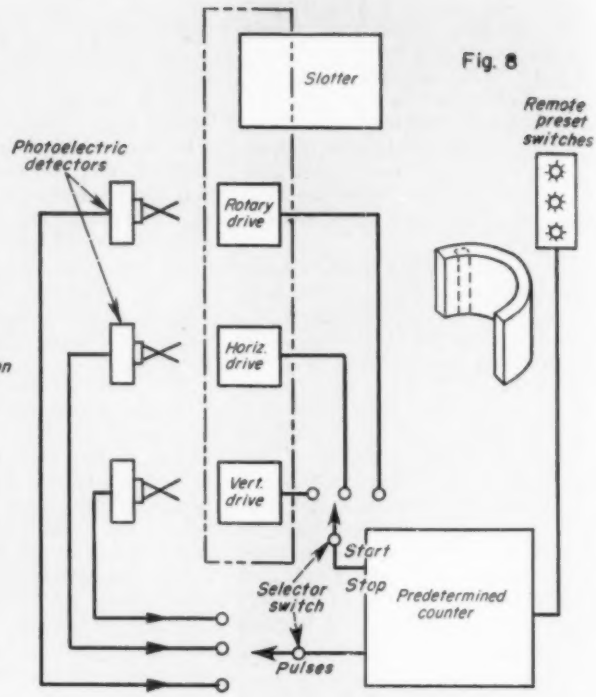


Fig. 8

Fig 6—Diagram illustrating methods used on hinge shearing machine to measure length of stock and to vary speed of drive.

Fig 7—Use of electronic counter as tachometer. Pulses are generated by the steel segment rotating through the coil's magnetic field as shown in sketch a, above. In sketch b, the pulse is caused by the light beam passing through the slots.

Fig 8—Tool movement on a slotting machine is controlled by means of electronic counter. Counter is arranged to stop each of the three drive motors after a set number of revolutions.

tronic counter takes on the functions normally assigned to cams, gears, chains, patterns and other methods of program control. In performing functions the decade counter has advantages: lack of moving parts to wear, slip or require lubrication; instantaneous reset; infinite capacity for variation; freedom from speed limitations.

Applications

A problem is presented in the counting and packaging of many small parts which because of uneven size and irregular shape do not flow freely. The single file rate at which they can be counted is necessarily low. The speed can be multiplied, however, by a multichannel feeder and detector, which can be seen in Fig. 5 as incorporated in a packaging machine.

Tacks, screws or similar objects are shake-fed through parallel channels with a photoelectric detector for each. All counts, even those which occur simultaneously, are totalized in a dual predetermined counter which is used to control the vibrator drive. In an arbitrary batch of 1,000, the count of 980 would be used to stop the multichannel feed and cut in a single channel dribble feed. Any extra counts accumulated from the multiple feed are compensated for in the dribble interval. At the exact count of 1,000, the dribble feed is stopped, providing absolutely accurate automatic packaging.

The photoelectric type of pickup, which is often chosen where a count must be accomplished without physical contact, works well with electronic counters. Since the circuits have low inertia and require little driving power, a change in light intensity of only 20% serves for actuation. Packaged food labels are counted by the slight interruptions of a photocell beam caused by register marks where the light is trained through the translucent paper as it is fed from large rolls.

In the cracker-packing machinery photoelectric detectors are used for sanitary reasons to batch the crackers in predetermined quantities as they are fed from sponge rubber conveyors.

A different method of detection is employed to cut specified lengths of door hinges from strips which are manufactured in long stock dimensions. The number of "knuckles", spaced one-quarter inch apart in the hinge barrel, are counted by a steel-tipped stylus. The base of this stylus is suspended in an electromagnetic field, in which a voltage change is induced by any slight displacement.

Each time the stylus tip passes between hinge sections, a count is registered.

A dual electronic counter controls the rate of speed at which the material is fed to the shear. As shown in the block diagram, Fig. 6, a high speed roller is engaged during the first count interval. Just short of the shearing point, the counter brings the slow speed drive into position. When the hinge has been cut at the end of the count, re-cycling of the counter takes place.

On an aluminum rolling mill electronic counters are being used to obtain information on one operational sequence from three different standpoints. Total running time of the mill is gaged from revolutions of the main drive. An electromagnetic pickup on the flywheel generates a pulse for each revolution. Disturbance of the coil's magnetic field, as in the case of the stylus mentioned above, is the source of this pulse.

The lineal footage of the aluminum stock after each pass through the rollers is measured in somewhat similar fashion. A friction wheel of nonferrous material, riding on the aluminum sheet, has steel slugs imbedded in its perimeter at precise intervals. Pulses are derived from these slugs by another pickup coil. Each pulse represents a length of stock equivalent to the spacing between slugs.

To certify that counts are registered only while the friction wheel is in contact with the aluminum stock, and also to total the number of passes through the rollers, a relay is interposed between wheel and counter. By grounding the relay's circuit through the aluminum at a precise point, counting can be started and stopped as the ground connection is made or broken. Relay operations, of course, equal the number of passes.

In gathering piece-work payroll data from the operation of a punch press, an electronic counting interlock has been put to good use. Each time the press drives home, the shock is registered in an impact-sensitive detector and a pulse passed on to a short interval memory tube. When the material is ejected from the press, a mechanical finger observes that a hole has been punched and routes a second pulse to the same tube. Only then is the counter actuated. Accidental operation of the press while empty accordingly has no effect on the counter. Neither will a count result from spurious pulsing of the hole detector. Duration of memory in the pulse-verifying circuit spans the lap between punching and ejection, but is short enough to make deception impossible.

Determining the speed of shaft revolutions with many conventional means becomes unsatisfactory at the higher ranges of speed. Accuracies within 5% are difficult to achieve. Moreover, the taking of meter readings involves the human element so that errors often occur because of carelessness, incorrect interpolation, etc. The electronic tachometer overcomes both shortcomings, providing an accuracy of ± one rpm regardless of speed and eliminating confusion in observation by exhibiting the reading in digital form.

An external aluminum disk coupled to the main shaft is arranged to generate 60 pulses for each revolution. Either a photoelectric or electromagnetic detector, as illustrated in Fig. 7 is trained on the disk perimeter. A count taken for exactly one second is read directly as rpm (60 times rps). If the disk drive gear ratio is other than unity and/or the disk is designed to give other than 60 pulses per revolution, this can be compensated for by a proportional change in the time base period.

Counting for exact intervals creates the need for precise time cycle generators such as a crystal oscillator.[4] So-called resonant circuits will pulse 100,000 times a second in response to excitation of a 100 kc crystal whose accuracy is within one or two parts per million. Therefore, each pulse counted represents 10 microseconds. Applying this high frequency as an input to five decades in tandem, for example, each of which divides by ten, produces a pulse per second at the output. By methods discussed previously, a predetermined count of 60,000 could be used to obtain an interval of 0.6 second. Any desired interval may be selected up to several seconds and, with higher frequency time bases, in increments of 0.000001 second or smaller.

Flexibility of control is gained in a new hydraulic slotter whose cutting head is positioned in three planes (rotary, horizontal and vertical) by an electronic counter. As indicated schematically in Fig. 8, the feed control is connected to a predetermined counter and photoelectric pickups are used to detect revolutions of the three drives. Because of the strict ratio existing between inches of tool travel and motor shaft revolutions, a count may be preset to stop the drive at any precise point. The preset switches in this application are mounted remotely from the counter on a pendant control box convenient to the work itself.

A method of automatic sorting by weight is illustrated in Fig. 9. With this arrangement, parts on a conveyor system are weighed in a fraction of a second, with no drag on the weighing mechanism to impair its accuracy and with any desired degree of weight discrimination between parts.

As the piece or carton which is to be sorted reaches the section of conveyor which acts as a weighing platform, deflection of the scale arm takes place. This deflection causes a slotted device to move a proportional distance through a beam of light trained on a phototube. As the beam is alternately passed and blocked, the interruptions are registered in an electronic counter. The total accumulated when the scale returns to normal is sensed by a thyratron circuit. Thereupon the appropriate gate solenoid from among several is energized to channel the material to its proper bin. Having completed this operation, the counter is reset automatically for the next measurement.

It is seen that a broad field of measurement and control is within the scope of the electronic counter. The design engineer will find it an invaluable tool for problems involving quantity, length, volume, time, velocity, frequency or revolution.

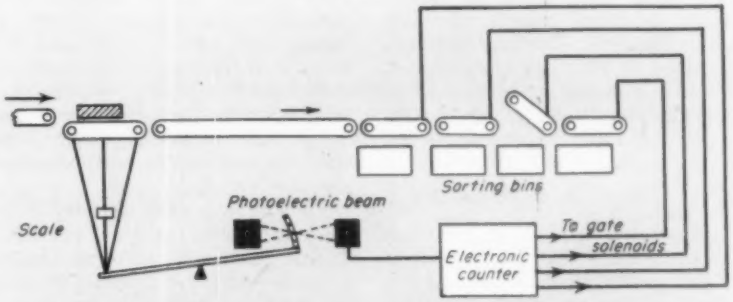


Fig 9—Arrangement for high speed weighing of units moving along a conveyor. Scale mechanism moves slotted piece, which breaks light beam into pulses for input to counter. Thus, weight can be represented as a count.

Engineering Uses for Rubber Adhesives

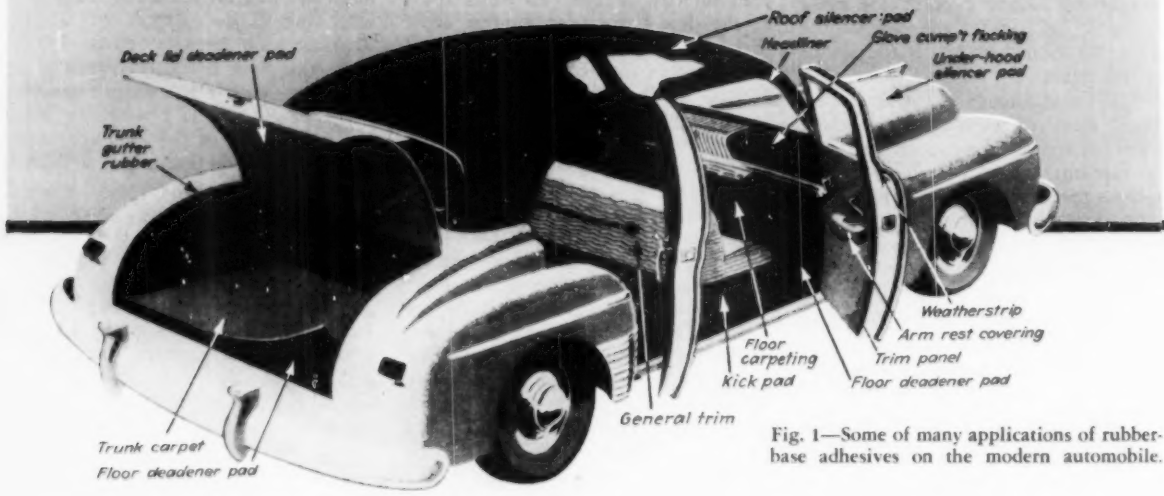


Fig. 1—Some of many applications of rubber-base adhesives on the modern automobile.

R. S. PIPER
Adhesives and Coating Division
Minnesota Mining and Manufacturing Company

RUBBER ADHESIVES have at least one property which sets them apart from most other types—they produce non-rigid bonds. They flex and stretch under stress and, unless the elastic limit is exceeded, recover when the load is removed. They are also distinguished by their ability to support at least a moderate load immediately after the joint is made. Ordinarily, no clamps, fixtures or other temporary shoring is necessary to hold the surfaces together until bond strength is developed.

Composition-wise, rubber adhesives cover practically the entire field of natural and synthetic, new and reclaimed rubbers. Natural rubber has the advantage of good resilience and tensile strength, but has many shortcomings when compared with some synthetics. Take petroleum fuel resistance for example: natural rubber swells and softens when soaked in gasoline, while certain synthetics are virtually unaffected after immersion for several months. Table I compares the rubbers most commonly used in adhesives. Properties of adhesives compounded from them closely parallel those of their parent rubbers. Note particularly, the properties where synthetics excel natural rubber and also that several types are lower in cost.

Reclaimed rubbers, primarily natural, but now including some synthetics, are important lower cost materials from which many excellent adhesives are made.

All adhesives offer definite advantages over other fastening methods. Almost invariably they are inconspicuous—usually to the point of going completely unnoticed by the user of the article. Therefore, they frequently permit improved styling and appearance. Functionally, adhesives give continuous contact between the mating surfaces, thereby distributing the load evenly over the entire joint area and eliminating the local stress concentrations which are normal with most mechanical fastening devices. This often permits the use of thinner gage materials. There is no danger of rupture from nail, screw or rivet heads, stitching, stapling or other attachers while the joint is under stress. Adhesive joints can often be made to serve another function—sealing the joint against leakage of air, dust or fluids.

New and unique design possibilities exist where other fastenings would be quite impractical. The modern automobile, with its all-steel construction, would be difficult to assemble without adhesives, as can be seen from Fig. 1. Large volume producers like the automobile industry often require specially compounded adhesives to achieve the optimum in handling properties to suit individual assembly line methods and schedules.

There are three main things to keep

in mind when designing with these adhesives:

(1) Allow for the maximum possible contact area in a joint. Adhesives have less unit strength than metal fastenings so a greater contact area must be utilized to support a comparable load. For instance, a lap joint should provide sufficient overlap to insure adequate strength.

(2) Put the maximum amount of adhesive film to work. That is, consider the manner in which load stresses will be applied and try to have them acting in the most advantageous direction. It is illustrated in Fig. 2(a) and 2(b) that tensile and shear loadings bring the whole adhesive film into play and consequently give the greatest strength. Next in order of preference is the cleavage type bond, Fig. 2(c). The peelback bond, Fig. 2(d), utilizes only the edge of the adhesive film, and gives the lowest strength.

(3) Investigate thoroughly the properties of the adhesives and take advantage of the knowledge and experience of the adhesive manufacturer early in the design plan. A proper balance between service requirements and adhesive properties and limitations is necessary.

In selecting an adhesive, the service conditions to which the adhesive bond will be subjected are of vital importance. The production facilities, sequence of assembly operations and time schedules, and shop conditions with respect to ventilation, fire hazards and other factors also have an important bearing on the selection of the right product.

Table II provides a check-list of service conditions and other factors to consider when selecting an adhesive.

Application Techniques

Proper application is one of the most important contributions to successful usage. Good design and good judgment in selecting the best product for the job matter little if the adhesive is carelessly or improperly applied.

(1) Surface Preparation—Improper surface preparation is probably the greatest single cause of failures. Cleanliness is the keynote. Adhesives cannot be expected to adhere to wet, oily or dirty surface. If an adhesive has been recommended to bond certain materials together, the situation may be altered completely if a paint or other surface coating or treatment is employed before the adhesive is applied. There may be little or no adhesion to that particular coating. Or, the adhesive may attack and lift the surface coating and produce a poor joint, even though it adheres well to the coatings.

(2) Spreading Methods and Equipment—There are many methods of distributing the adhesive over a sur-

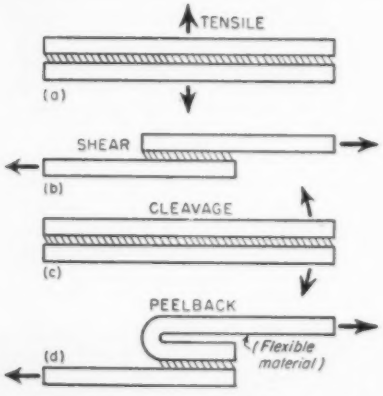


Fig. 2—Basic types of adhesive bonds —showing load stresses, (a) Tensile, (b) Shear, (c) Cleavage, (d) Peelback. Shaded areas represent the adhesive films; arrows, the directions of stress.

Table II—Designers' Check-List for Submitting Adhesive Problem to Supplier

1. Materials—Describe specifically the materials which are to be bonded and what surface treatments, if any, they have had—offer to submit samples.

2. End Use—Describe the finished article or assembly on which it is to be used and where the adhesive bond fits into the picture—use a sketch if words do not adequately describe.

3. Stresses—Indicate the direction and magnitude of forces acting on the bond and whether it is a constant or intermittent load.

4. Service Conditions—Note if the adhesive bond will be subjected to:
   Temperature extremes—give range
   Exposure to solvents, oils, chemicals, etc. and the extent or constancy of such exposure.
   Exposure to water, weather, sunlight

5. Application—State any preferences or limitations on how the adhesive is to be applied.

6. General—List any other factors such as color, odor, flammability, etc. which are important.

Table I—Comparison of Rubbers Used in Adhesives

Rubber Type	Price per Dry Lb (a)	Specific Gravity	Resiliency	Tensile Strength	Ultimate Elongation	Natural Aging	Hi Temp Aging (b)	Aliphatic Resistance	Best solvent (c)
Natural	60¢	0.93	1-Best	1-Best	1-Best	3-Mod.	1-Best	4-Poor	Petroleum
GR-I (Butyl)	21¢	0.91	3-Mod.	4-Fair	3-Mod.	1-Best	2-Good	4-Poor	Petroleum
GR-S	26c	0.94	3-Mod.	4-Fair	4-Fair	4-Fair	4-Fair	4-Poor	Petroleum
Neoprene	45¢	1.25	2-Good	2-Good	2-Good	2-Good	3-Mod.	3-Mod.	Aromatic
Nitrile (Buna N)	50¢	1.00	3-Mod.	3-Mod.	4-Fair	4-Fair	4-Fair	2-Good	Ketone
Polysulfide (Thiokol)	$1.00	1.27	4-Poor	5-Poor	5-Poor	2-Good	5-Poor	1-Best	Aromatic

face. The products impose some limitations, but usually an adhesive can be selected which will permit the most advantageous method for the prevailing production facilities.

Brushing (Fig. 3) and spraying (Fig. 4) are the most common means of depositing adhesive films. There is often a difference of opinion about the spray-ability of adhesives. It should be pointed out that they do not usually give a smooth, continuous appearance as do paints and lacquers. Often the film is spotty and globby. Nevertheless it will be a satisfactory film from a functional standpoint.

Trigger operated pressure oil cans (Fig. 5) or pressure fed flow guns are in less common use, though satisfactory for spreading adhesives. The latter sometimes have follower brush attachments which assist in distributing the liquid over a wider surface area.

The roll coater (Fig. 6) is an excellent machine for coating sheet stock with rubber adhesives. Several types are in comon use, but they are fundamentally similar in principle. Basically, a pickup roll is positioned to turn with the bottom partially immersed in a trough containing the adhesive. The pickup roll contacts a transfer roll which coats the bottom of the sheet stock as it is fed between it and a pressure roll mounted above it. The quantity of adhesive deposited is easily regulated by adjusting simple controls on the machines.

Knife coating is another effective method for spreading films of uniform thickness. The equipment consists of a bed over which a "blade" is adjustably mounted. The blade need not be particularly sharp—in fact, it is sometimes a bar or rod. A quantity of adhesive is fed so as to lie against one side of the blade. As the stock to be coated is drawn under the blade, a film of uniform thickness is deposited on its top surface. Film thickness can be regulated by careful adjustment of the distance of the blade above the bed, taking the thickness of the stock into consideration.

Parts having unusual contours, but which must have adhesive only on the faces of their projections, can be coated advantageously with a stamp pad device. Adhesive is fed to a shallow pan from an auxiliary reservoir and the flow is adjusted so as not to exceed a desired level. A piece of felt is placed in the pan to absorb the adhesive and provide a contact surface. Parts are simply pressed onto the felt to get a coat of adhesive.

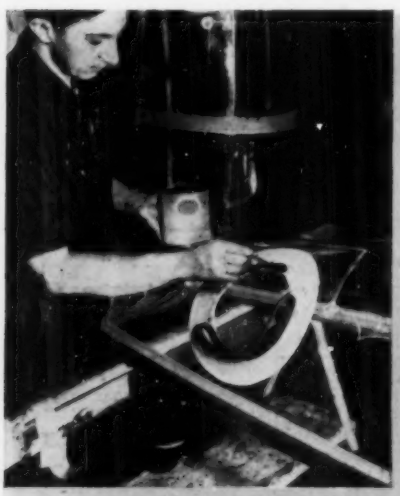
Where only certain areas of a surface are to be adhesive coated, a silk screen is often used. An adhesive pattern of considerable accuracy can thus be registered on a surface. Similarly, certain types of printing machinery can be adapted to apply adhesives in almost any desired pattern. Such methods are particularly well suited to the application of flocking adhesives, where lettering or a well-defined design is desired.

(3) Bonding Techniques—Once it is decided how the adhesive is to be spread on the bonding surfaces, one must choose the technique for making the bond. There are several basic methods and enough variations of each to accommodate almost any production requirements. The main thing so far as the adhesive is concerned, is to dissipate the solvent so that the film can develop strength. Solvent is useful only to give a consistency for application—once applied it is a liability and must be released before the adhesive can function. A few common bonding techniques are:

(a) *Wet Bonds*—Adhesive is applied to one surface (the least porous) and the other surface brought into contact at once. This method is suitable where at least one of the surfaces is porous enough to permit passage of the solvent. Light weight insulating materials and fabrics are usually bonded in this manner.

(b) *Tacky Bonds*—Adhesive is applied to one or both surfaces and allowed to dry until an aggressive tack is developed—that is, when the film feels very sticky, but no longer transfers to the finger when touched. This open drying time is usually specified by the manufacturer generally as a minimum and maximum drying time after spreading adhesive. Allowances must be made for variables such as temperature, humidity and ventilation, however. Surfaces are brought together during this tacky stage and pressed down firmly to insure intimate contact of adhesive films. The choice between coating one or both surfaces will depend upon the nature of the adhesive and the surfaces being bonded; ordinarily longer open times are possible and higher strengths are realized when both surfaces are coated.

(c) *Reactivated Bonds*—Reactivation methods are useful where both surfaces are impervious to the passage of solvent. They are also advantageous where areas to be bonded are large and it is difficult to have the



Republic Aircraft Corp.

Fig. 3—Brush application of adhesive on rubber gasket on aircraft part.

Honeymetal Products Co.

Fig. 4—Spraying a rubber-base adhesive on cardboard core of metal-sheathed partitions, showing an irregular and somewhat globby spray pattern.

whole surface at the optimum drying stage at the same time. Bonding high pressure laminate sheeting to table or counter tops is one instance where this technique is used. Here both surfaces are coated with adhesive and dried completely. Sometimes it is possible to pre-coat surfaces several days or even weeks in advance if protected from dust contamination. The bond is effected by reactivating the adhesive films with heat or solvent.

Heat Reactivation—Adhesive-coated surfaces are joined and the assembly is heated in an oven with infra red lamps or other suitable means until the two films soften and fuse together. The temperature at which fusion takes place may be obtained from the manufacturer, or it can be easily established after a few trials. Time must be allowed for the adhesive film to attain the proper temperature. Taking into consideration the fact that the materials being bonded may act as insulators and retard the transfer of heat to the film.

Solvent Reactivation—Dampening one of the adhesive films with a suitable solvent, then joining the surfaces, is another variation of the reactivation process.

(d) *Pressure-Sensitive Bonds*—These are the simplest bonds to make, but unfortunately there are few satisfactory adhesives of this type. They retain their tack for long periods and the bond is made simply by contacting the coated surface. Other types are pressure sensitive only to themselves, that is, when two coated surfaces are brought together. Care must be taken to protect pressure sensitive adhesive films from contamination with dust or other foreign matter until they are joined.

(e) *Curing Bonds*—Some adhesives must be cured to develop their strengths. There are two main types of curing adhesives—liquids and films. The liquid types generally require an accelerator to effect a cure. This accelerator has a definite working life after its addition. Often these adhesives consist of 100 percent nonvolatiles, although some contain sufficient volatile liquid to give them a consistency for easy application. Some types are marketed in sheet form, either as unsupported films or on carriers. They are useful where no initial tack is desired and where no solvent can be tolerated.

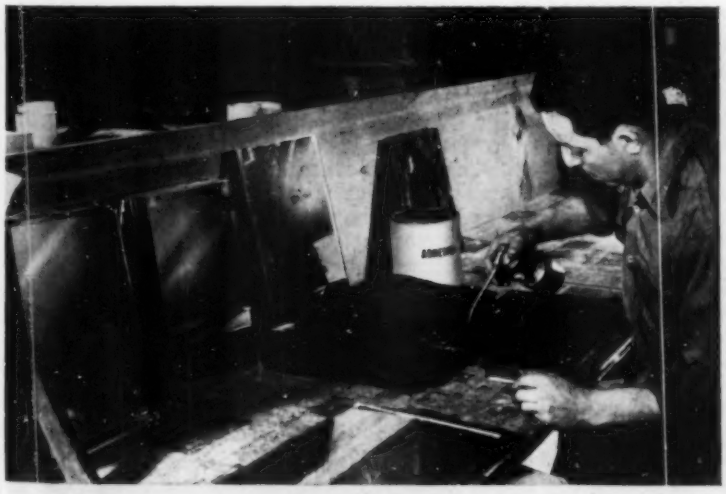
(f) *Combination Bonds*—Combinations of the above techniques can be used. For instance, it is possible to precoat one surface well in advance, dry it thoroughly, then complete the bond by contacting it with a freshly coated wet or tacky film on the other surface. Sometimes it is feasible to coat two unlike surfaces with two different adhesives that are compatible and will form a bond when joined.

Special consideration must be given to bonds on certain types of materials. It will sometimes be found that an adhesive coating is so completely absorbed by a very porous surface that little or none is left on the surface. There are several solutions to this problem. Several coats may be applied until there is enough remaining on the surface to give a good bond. Another technique is to saturate the surface temporarily with a solvent that is incompatible with that in the adhesive. A surface saturated with a petroleum naptha, for instance, will prevent the penetration of a water-dispersed adhesive. After the film has been spread, the naptha evaporates, leaving the adhesive to contact the mating surface. The reverse technique may be used where petroleum naptha is the adhesive solvent—by moistening the surface with water.

Occasionally a material is encountered which seems to defy all attempts to bond it. A type of coating which will adhere to it, can usually be found, however. This coating is then used as a primer and an adhesive used that will bond to the primer.

Many of the reasons for poor bonds are simple and readily apparent. Such things as "starved joints" where not enough adhesive remains on the surface to produce a bond, are quite easily detected. Likewise it is not difficult to recognize a "dry bond" where the adhesive was allowed to get too dry before joining. Here the bonds separate readily with the films still intact, showing no evidence of having knitted together.

Sometimes a good bond rubber adhesive will lose strength markedly after a day or two. There are several possible reasons. Some rubbers are compounded with a wax that acts as a mold release or as a lubricant for extrusion; it also forms a protective surface film to improve sunlight aging. This wax "blooms" on the surface and weakens the bond. Other rubbers and many flexible plastics such as vinyls contain plasticizers that migrate into the adhesive film, soften it and lessen its strength. An adhesive must be chosen which is not affected by the plasticizer present in each case.



J & M Novelty Co.

Fig. 5—Applying adhesive with trigger operated pressure oil can to adhere felt to back of mirror. Adhesive is applied only at edges.

Mastermade Wood Products

Fig. 6—Roll coating adhesive on covering for portable radio cabinets.

Resistance Wire Computing Device for Solving Algebraic Equations

C. V. RAMAMOORTHY and W. W. SOROKA
University of California

BASIC POTENTIOMETRIC NETWORKS for obtaining the product of two or more factors, and resistor circuits for adding several factors, were discussed in the article "Resistance Network Analogue for Solving Vibration Problems," PRODUCT ENGINEERING, April 1951, p 103. Also, in that article the theory of a method was developed for combining such networks and circuits in the solution of vibration problems.

This present article describes the construction of such a simultaneous equation solving device, its operation, and the results obtained in using the device to solve a problem of vibration isolation in which coupling exists between translation and rotation. These experimental results obtained on the computer are compared with the theoretical results of an exact analytical solution for the steady-state response of the system.

Designed as a low cost general purpose computer, the construction of the simultaneous equation solver is indicated in Fig. 1. This machine employs 64 potentiometers, the slide wire of each is a 60 in. length of Nichrome V wire. The potentiometers are independent of each other and have jacks at their ends to permit interconnections.

The wires are stretched horizontally across the face of a large sheet of plywood at one-inch intervals. Nickel-plated brass rods mounted in front of the wires serve as supports for the sliders contacting the wires and also as a means for transmitting the voltage at the slider to other points in the machine. Small wooden block sliders on the rods carry flexible phosphor-bronze springs that contact both the rod and the wire. Where several potentiometers are assigned to the same variable or to the same coefficient, holes in the blocks permit ganging several sliders together by means of a connecting wood strip and dowel pins. When ganged in this manner, several sliders can be moved as a unit instead of by individual adjustment.

Two wire sizes are arranged in three groups on the board. The middle group consists of 32 potentiometers of No. 24 wire, each having a resistance of 8.0 ohms; these are designed to serve primarily for representing the unknown variables. Above and below this middle group, there is a group of 16 potentiometers of No. 34 wire, each having a resistance of 82 ohms; these serve primarily for representing the coefficients in the equations.

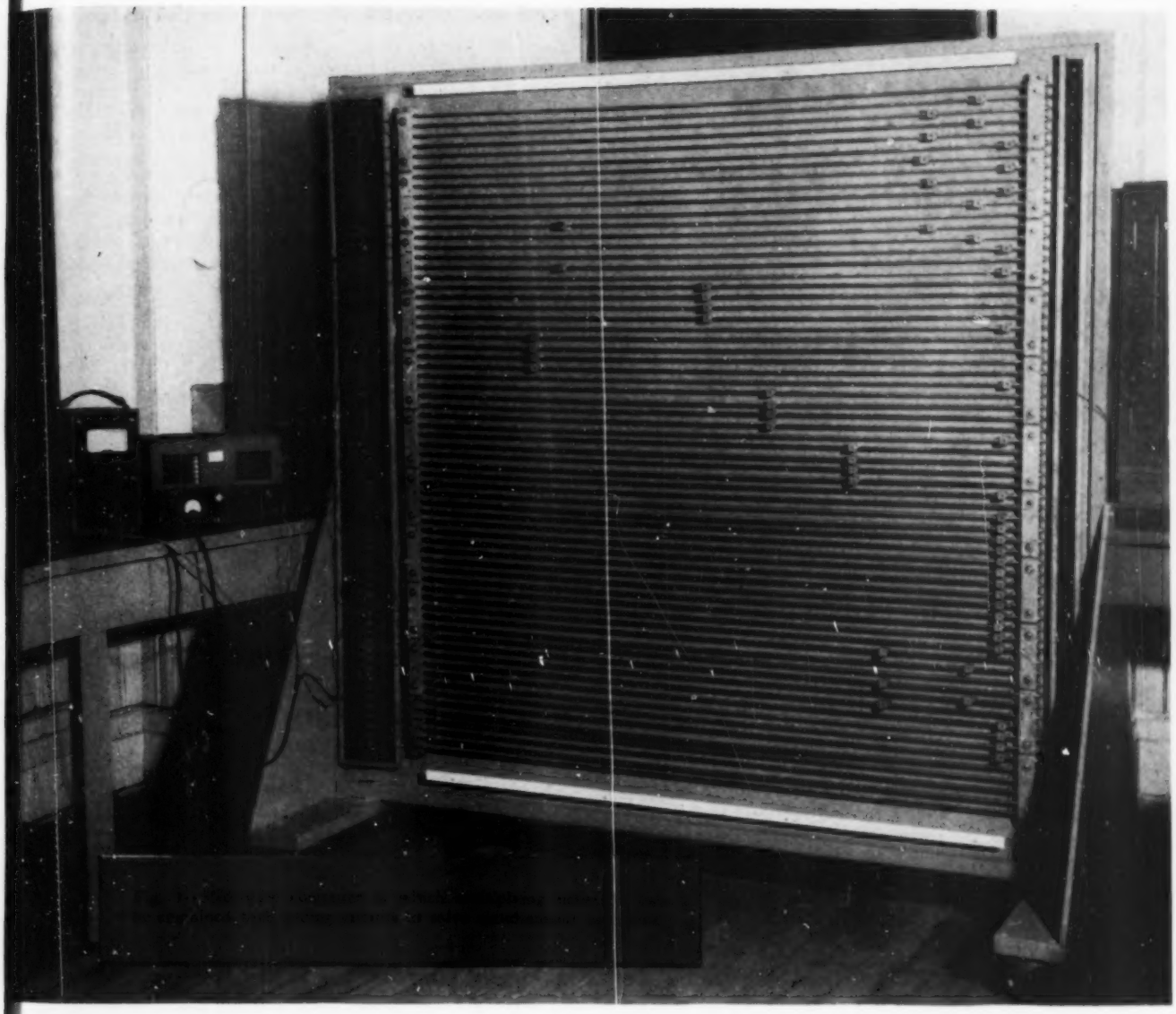
Since the lighter wires are usually fed by the heavier wires, the resistance of the lighter wires should be high enough to insure that as little current as possible is drained from the heavier wires. This precaution is necessary if the position of the slider is to be directly and linearly related to the voltage at the slider. Wires much heavier than No. 24 were found to have too low a resistance for accurate measurement, also they were too stiff to stretch by hand between binding posts. Wires much lighter than No. 34 broke during manipulation of the sliders.

The capacity of the machine can be increased with only minor changes in design. By arranging each slider so that the electrical connection between it and the rod can be made or broken at will, several sliders can be placed on each coefficient wire; only one, of course, being operative at any one time.

Since a coefficient potentiometer is always cascaded with a corresponding unknown variable potentiometer, all coefficients multiplying this one variable in the set of simultaneous equations may be set by as many sliders on the one coefficient potentiometer, and then connected into the circuit one at a time as attention is shifted from equation to equation.

Thus to solve a set of, say, six simultaneous equations with six unknowns would require only six coefficient potentiometers with six sliders on each (instead of thirty-six with one slider on each as is the conventional case), six variable potentiometers (instead of thirty-six as would be set up on this computer as it now exists), and six constant-term potentiometers.

To the left of the bank of potentiometers in Fig. 1 is shown a column of single-pole double-throw switches for sign changing. Throwing a switch to the left connects its common terminal to a bus bar supplied with +2 volts, while throwing it to the right connects its common terminal



to a bus bar supplied with —2 volts. These voltages are supplied by a General Radio 0 to 10 volt Variac Rectifier unit set at 4 volts. The plus and minus two volts is obtained by crossing the output terminals of the rectifier with a 100 ohm, 10 turn Helipot potentiometer the center tap of which is the common ground for the entire computer.

Operation of the Computer

Each pair of straight wire potentiometers representing one term in an equation must be connected to either the plus bus or the minus bus, depending on the sign of the term. Since the term usually contains an unknown that may be either plus or minus, the final setting of the switch corresponding to this term will be determined in the course of balancing out the equations.

If balance cannot be obtained on, say, the plus setting of the switch, the switch is thrown to minus and balancing accomplished with this setting. The technique of operating the computer for most rapid solution of equations is quickly developed with experience.

In connecting various groups of potentiometers to the plus and minus bus bars, the voltage-dividing Helipot becomes unequally loaded on the two sides of the center tap, with the result that the rectifier output voltage is not equally divided between the two bus bars. This situation can be corrected by readjusting the center tap position to equalize the voltages. A better method was found to be that of maintaining equal numbers of switches on both plus and minus settings by using wires not assigned to any equation simply as load equalizers, or by changing all the signs in one or more of the equations.

An additional slide-bar is provided at the top and the bottom of the computer, either of which can be used with a lower resistance wire as a voltage divider. By using a voltage divider of the smallest practicable resistance, the loading effects of the higher resistance potentiometer banks become small. Instead of a power supply with potential divider, identical batteries with low internal resistance, or separate voltage-regulated power supplies might be used to supply the plus and minus bus bars.

The addition of the various terms occurring in an equation is accomplished by means of precision adding

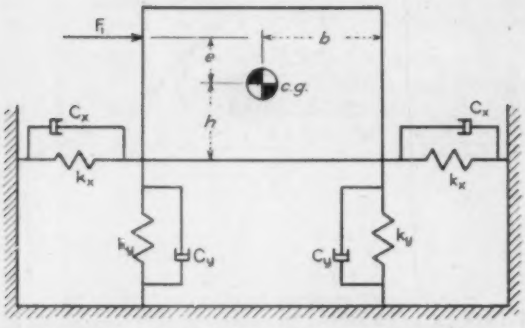


Fig. 2—Machine on resilient mounts that permit both translational and rotational movement.

resistors having a large ohmic value as compared with the connected potentiometers. In the present computer, 100,000 ohm vacuum-sealed precision resistors of plus or minus one-half percent tolerance are used. These appear in Fig. 1 as small elongated horizontal elements interspersed among the switch handles near the top and near the bottom of the switch panel.

The setting of the slider on each potentiometer must be expressed as a ratio to the full length of the potentiometers. Hence, the slider setting can have values ranging from zero to unity. Since the slider settings represent the values of the variables and the coefficients, it is apparent that these values must not exceed unity. These conditions can be realized easily. By dividing each equation through by the largest coefficient present in that equation, all coefficients will be reduced to values of unity or less.

If, during the solving process, it becomes evident that balance cannot be obtained without running one or more of the variable sliders off scale, the values of the corresponding variables must exceed unity. In such event, each variable suspected of having a value in excess of unity must be divided by a number sufficiently large to reduce it to unity. This number, then, is a scale factor that is inherent in the nature of the machine. One then solves the equations for the reduced variable and multiplies the value obtained by the scale factor to obtain the correct result. Different scale factors are used for the different variables as needed.

It should be pointed out that whenever a variable is multiplied or divided by a given factor, the coefficients of that variable in all the equations must be divided or multiplied by the same factor in order to keep the sense of the equations unchanged. A resetting of the coefficients, therefore, is necessary whenever a new scale factor is introduced.

If it is suspected at the start of the solution that one or more variables will go off scale, it is good procedure to apply scale factors sufficiently large to keep the variables within bounds. Such a procedure is likely to lead to rather inaccurate results at the end of the first solution, but will take less time than the fumbling around that is likely to occur when sliders begin to go off scale. After getting a first rough solution, one can then readjust the scale factors to more reasonable values and proceed rapidly to a more accurate solution.

Too small a variable is also undesirable from the standpoint of accuracy. Hence, if some variable tends to become too small it may be multiplied by a number sufficiently large to bring about a reasonably accurate setting of the potentiometer.

Machine Settings for Solution of a Vibration Problem

To facilitate presenting a comparison of the experimental results obtained on the computer and the theoretical results obtained from an analytical solution, the problem discussed in "Mechanical and Electrical Analogues for Vibration Isolation Problems," PRODUCT ENGINEERING, February 1950, p 104, will be further studied here.

The problem is indicated in Fig. 2, which shows a common arrangement of a machine on resilient mounts that permit both translational and rotational movement. The impressed force F_1 acting above the center of gravity produces both a force at and a moment about the center of gravity.

Where

m_1 = mass of the isolated body
r = radius of gyration of the body about its center of gravity
x_1 = horizontal displacement of the center of gravity during vibration
θ = angular rotation of body during vibration, radians
ω = frequency of the exciting force

and the other parameters are as defined in Fig. 2, for this system the equations of motion are:

$$m_1 \ddot{x}_1 + 2\, c_x (\dot{x}_1 - h\dot{\theta}) + 2\, k_x (x_1 - h\theta) = F_1 \sin \omega t \quad (1)$$

$$r^2 m_1 \ddot{\theta} + 2\, c_y\, b^2 \dot{\theta} - 2\, c_x (\dot{x}_1 - h\dot{\theta}) h + 2\, k_y\, b^2 \theta - 2\, k_x (x_1 - h\theta) h = e\, F_1 \sin \omega t \quad (2)$$

Following the procedure suggested in the February 1950 article, Eqs (1) and (2) can be simplified in appearance and made to resemble each other more closely by means of the following substitutions:

$$h\,\theta = x_2;\ m_1 (r/h)^2 = m_2;\ 2\, k_x = k_1;\ 2\, k_y\, (b/h)^2 = k_2;\ 2\, c_x = c_1;\ 2\, c_y\, (b/h)^2 = c_2;\ \text{and } F_2 = (e/h) F_1 \quad (3)$$

The equations of motion then become

$$m_1 \ddot{x}_1 + c_1 (\dot{x}_1 - \dot{x}_2) + k_1 (x_1 - x_2) = F_1 \sin \omega t \quad (4)$$

$$m_2 \ddot{x}_2 + c_2 \dot{x}_2 - c_1 (\dot{x}_1 - \dot{x}_2) + k_2 x_2 - k_1 (x_1 - x_2) = F_2 \sin \omega t \quad (5)$$

For any specific system, Eqs (4) and (5) may be solved on the simultaneous equation solver and the response of the isolated mass determined for various configurations and magnitudes of the mass, springs, dashpots and force.

In view of the many possible combinations of these values, a considerable amount of time may be consumed in developing families of design curves, particularly if more than two degrees of freedom are involved. If one bears in mind the fact that the effects of changes in two different parameters of the system may cancel each other, leaving the response of the system unchanged, tests involving such counteracting changes may be eliminated with a corresponding saving in time.

By grouping the various parameters or variables into nondimensional groups, and varying the values of these groups, instead of those of the individual variables, from test to test, the possibility of counteracting effects is thereby eliminated, the minimum possible number of tests result, and the design curves so obtained are of more general applicability.

Consequently, Eqs (4) and (5) were nondimensionalized, prior to setting them up on the equation solver, by means of the following substitutions:

$$X_1 = x_1/x_{st};\ X_2 = x_2/x_{st};\ x_{st} = F_1/k_1;\ T = (\omega/2\pi)t;\ k_1/m_1 = \omega_1^2;\ k_2/m_2 = \omega_2^2;\ \omega_2/\omega_1 = f;\ \omega/\omega_1 = g$$

$$c_c = 2\, m_1\, \omega_1;\ m_1/m_2 = \mu;\ F_2/F_1 = \lambda;\ dX/dT = \dot{X};$$

$$d^2X/dT^2 = \ddot{X};\ c_1/c_c = C_1;\ c_2/c_c = C_2$$

resulting in the dimensionless equations

$$(g^2/4\pi^2)\, \ddot{X}_1 + C_1 (g/\pi)(\dot{X}_1 - \dot{X}_2) + (\dot{X}_1 - X_2) = \sin 2\pi T \quad (6)$$

$$(g^2/4\pi^2\mu)\, \ddot{X}_2 + C_2 (g/\pi)\, \dot{X}_2 - C_1 (g/\pi)(\dot{X}_1 - \dot{X}_2) + (f^2/\mu)\, X_2 - (X_1 - X_2) = \lambda \sin 2\pi T \quad (7)$$

The variable parameters in Eqs (6) and (7) are g, C_1, C_2, μ, f and λ as compared with m_1, m_2, c_1, c_2, k_1, k_2, F_1, F_2 and ω in Eqs (4) and (5), a reduction from 9 to 6. The amount of testing time is reduced by a factor much greater than 9 to 6 by this procedure.

Following the procedure of the April 1951 article, the nondimensional equations can be converted to algebraic form by substituting into Eqs (6) and (7) the expressions:

$$X_1 = A_1 \cos 2\pi T + B_1 \sin 2\pi T \quad (8)$$

$$X_2 = A_2 \cos 2\pi T + B_2 \sin 2\pi T \quad (9)$$

This substitution results in the four simultaneous algebraic equations

$$(1 - g^2) A_1 - 2g C_1 B_1 - A_2 + 2g C_1 B_2 = 1 \quad (10)$$

$$2g C_1 A_1 + (1 - g^2) B_1 - 2g C_1 A_2 - B_2 = 0 \quad (11)$$

$$- A_1 + 2g C_1 B_1 + [1 - (g^2/\mu) + (f^2/\mu)] A_2 - 2g (C_1 + C_2) B_2 = \lambda \quad (12)$$

$$- 2g C_1 A_1 - B_1 + 2g (C_1 + C_2) A_2 + [1 - (g^2/\mu) + (f^2/\mu)] B_2 = 0 \quad (13)$$

The parameters of the problem appear in the coefficients of the A terms and the B terms. These are set on the coefficient potentiometers of the machine and the A and B potentiometers adjusted for equilibrium of all four equations. The settings of the latter potentiometers then provide the magnitude of the steady state response of the system for the given values of the parameters. By varying the settings of the coefficient potentiometers and readjusting the A and B potentiometers to equilibrium each time, data are obtained for plotting families of response curves. Since the theory of such a machine has been described in detail in the article "Resistance Network Analogue for Solving Vibration Problems," PRODUCT ENGINEERING, April 1951, p 103, it will not be repeated here.

In the group of Eqs (10) to (13) only four unknowns are involved, but in solving the equations sixteen potentiometers are used to represent the four unknowns, sixteen to represent the coefficients, and two to represent the only constant terms present.

Application of the Computer

To demonstrate the use of the computer, Eqs (10) to (13) were solved to obtain response curves of the isolated system shown in Fig. 2 for two different values of damping in the dashpots. The values of the parameters used are:

SOLUTION I:

$C_1 = C_2 = 0.1$; $\mu = 0.1$; $f = 1$; and $\lambda = 0$

SOLUTION II:

$C_1 = C_2 = 1.0$; $\mu = 0.1$; $f = 1$; and $\lambda = 0$

Since the variables A_1, A_2, B_1, B_2 occur once in each of the four equations, four potentiometers were used to represent each of the variables. In Fig. 1, there may be seen four groups of sliders in the middle of the board, each group containing four identically-positioned sliders. The first group represents the value of A_1, the second group that of A_2, the third that of B_1, and the fourth that of B_2. The coefficients of the A terms and the B terms are set on the potentiometers above and below these groups.

Following the procedures outlined, the groups of A and B sliders were moved to and fro along the bars until each equation was in balance as indicated by a zero reading on a Millivac d.c. vacuum tube voltmeter shown to the left of the power supply. This procedure was repeated for a range of values of g (0.4 to 2.0) sufficient to cover the response peaks of the vibrating system. The values of the total amplitude of translation and rotation were obtained from the relations

$$X_{10} = \sqrt{A_1^2 + B_1^2}$$

$$X_{20} = \sqrt{A_2^2 + B_2^2}$$

The amplitudes X_{10} and X_{20} were also calculated analytically from the equations of motion of the system.

For comparative purposes the theoretical response curves for the conditions of Solutions I and II are plotted in Figs. 3(A) and (B) respectively as full lines, and experimentally determined values, obtained on the resistance-wire computer, are shown spotted on the analytical curve. The agreement is seen to be good.

Experience with the computer has shown it to be convenient to use. Some improvements have been suggested as a means for increasing the utility of the unit. Other ideas for improvement will undoubtedly arise with continuing use. Basically, the computer will continue to be a relatively inexpensive unit for the solution of simultaneous equations.

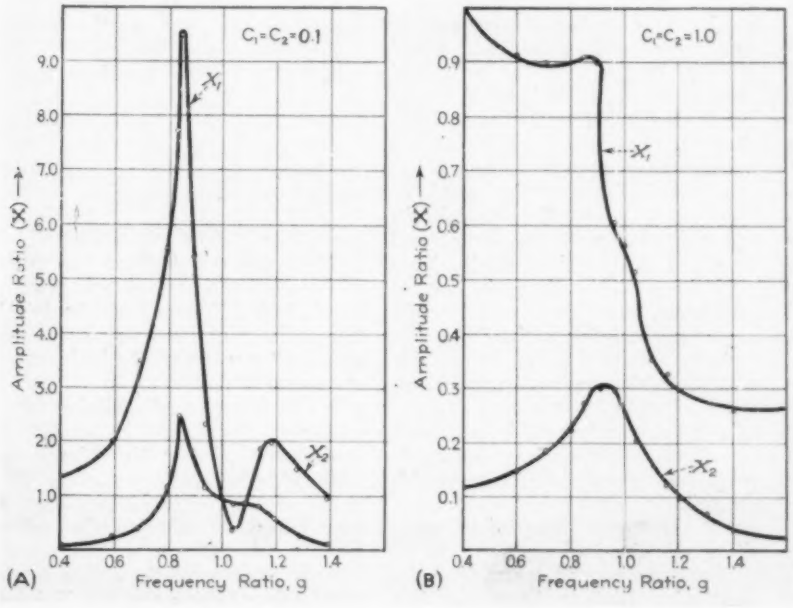
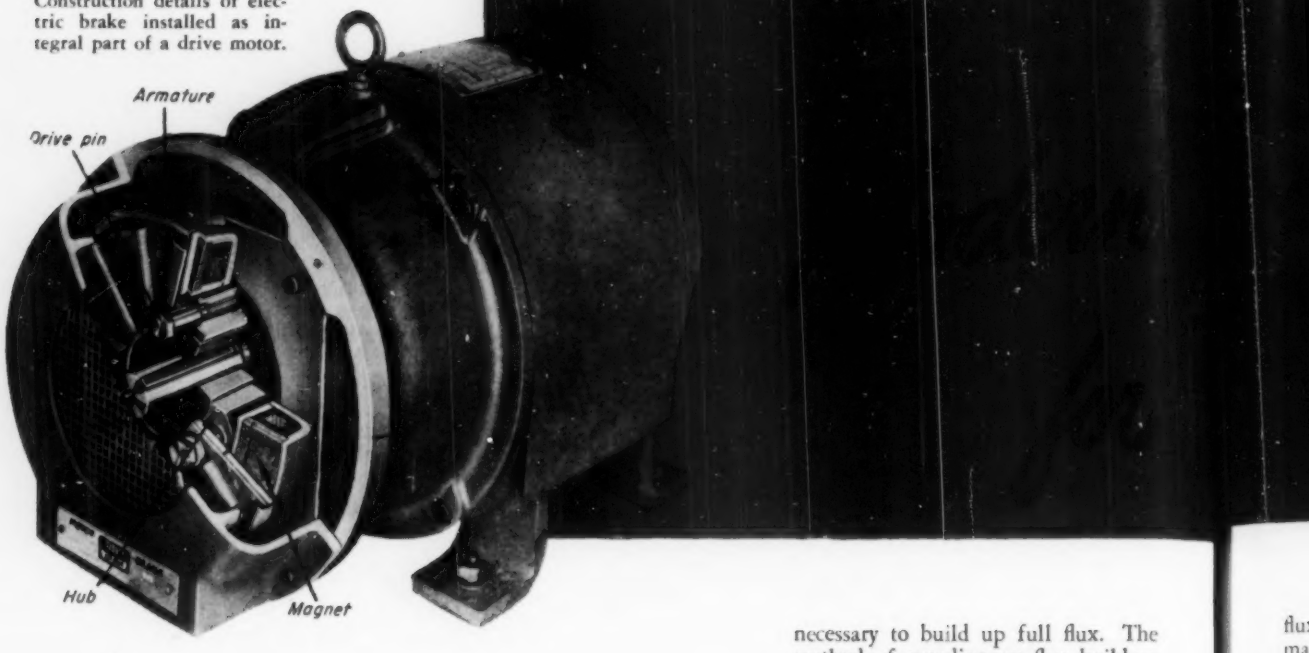


Fig. 3—Response curves of isolated system for two different values of damping in the dashpots. Full lines are theoretical response curves. Dots indicate experimentally determined values of amplitude ratio obtained on the resistance-wire computer using a range of values for the frequency ratio. Agreement of analytical and experimental data is seen to be close. (A) Light damping in dashpots. (B) Heavy damping in dashpots



Construction details of electric brake installed as integral part of a drive motor.

CERTAIN INHERENT CHARACTERISTICS make disk-type electromagnetic brakes and clutches particularly adaptable to the higher duty cycles and closer tolerances being sought constantly in modern machine applications. Since there is no mechanical linkage involved, the mechanical motion required for the armature to engage the magnet is minute and there is no friction loss due to the operation of such a linkage. Thus, the clutch or brake commences to engage immediately, just as soon as current starts to flow in the magnet coil. This produces high electrical and mechanical efficiency.

A second advantage of the electric brakes and clutches is flexible operation. This can be credited again to the minute motions involved in engagement and release and, also, to the absence of mechanical linkages. Because there are no mechanical linkages needed, the major variable determining the operation of these devices is the design of the control circuit. Performances ranging from a relatively slow, cushioned stop or start to rapid action—in the order of a few milliseconds—can be achieved as required.

The performance of the brake or clutch is determined by regulation of the flux set up by the electromagnet. The transmitted torque as well as the rapidity of the operation may be directly controlled by adjusting the total flux and its rate of build-up. And flux in turn is a function of the voltage applied to the electromagnet.

The clutch or brake electromagnet is so designed that the normal voltage as specified in the rating brings the magnetic flux to a value which saturates the steel in the magnet poles. At saturation, the armature is held against the magnet with sufficient force to permit transmittal of rated torque. The time taken to build up this flux, as well as the time taken for this flux to decay when the coil is de-energized, may be determined by means of an oscilloscope. If a higher than normal voltage is applied to the magnet, the oscilloscope shows that the time taken to reach the saturation point is shortened. If the applied voltage is lower than the normal value, the flux will not rise to the saturation point and the torque output is lowered. From the foregoing it is seen that a higher than normal voltage applied to the magnet shortens the time to reach full torque and increases the speed of application. A lower than normal voltage reduces the torque output and lengthens the speed of application.

If the applied voltage is low red sufficiently, the torque capacity will be lower than the machine's pull-in torque. This will cause the friction surfaces to slip continually and a slip-clutch or drag-brake results. Torque so applied may be readily controlled by either the manual or automatic positioning of a rheostat in series with the coil. In this manner, torque output of the magnet is varied to match changes in the load.

Where more rapid operation is desired it is possible to shorten the time necessary to build up full flux. The method of speeding up flux build-up is commonly referred to as over-excitation. This involves applying an initially higher voltage which materially increases the rate of flux build-up. If this initial voltage were maintained, the current would build up to a much higher value than the rating of the magnet calls for. The design of the magnet is such that with rated voltage and current, the steel in the magnet poles will be at magnetic saturation. Any increase in current over this rated value produces little increase in magnetic flux. The excess current represents power loss and if continued, leads to overheating. For these reasons, when the flux reaches its full value in an over-excitation circuit, the initial high voltage should no longer be applied. The control then can be automatically shifted to carry the magnet at rated voltage, which is sufficient to operate the brake or clutch unit at its rated torque output.

Over-Excitation Control

There are several effective methods of over-excitation control that provide the desired shift-over from the initial high voltage to rated voltage in the correct time to match the build-up of the magnetic flux.

A simple means of achieving over-excitation control is by the use of incandescent electric light bulbs in series with the magnet coil. The filaments of these light bulbs exhibit a great increase in resistance when going from a cold state to incandescence. Incandescence occurs in a time interval closely matching that required for

flux build-up time of a clutch or brake magnet under over-excitation conditions. Connected in series with the magnet coil, the lamps act as a variable resisto. in the circut. Thus, when the circuit is first closed, high voltage is applied across the magnet. As flux builds up and the lamps come to their incandescent condition the voltage across the magnet drops. The operating voltage across the magnet thus becomes constant at the rated value in a short time.

The curves in Fig. 1, taken from an oscillograph record, illustrate the decrease in operating time that is accomplished with over-excitation and a lamp bulb circuit. It is seen that the operating time with this method is less than one-third that required for flux build up with normal voltage applied.

A more complex method of over-excitation control uses the discharge of a capacitor to rapidly build up the flux. This is combined with a switching circuit that cuts in the rated voltage supply for holding. Thyratron tubes are incorporated in the switching element to electronically control the capacitor discharge. This method is referred to as capacitor-aided over-excitation. For actuation of the clutch or brake, the electronic tube switches the relatively high voltage of the capacitor across the magnet, establishing full flux almost instantaneously. Where the application calls for a fast shift over from clutch to brake operation, capacitor discharge is applied to both magnets. By reverse current, the clutch magnet is demagnetized while the flux is being built up in the brake. This prevents the clutch from hanging on momentarily after the brake is applied, which would defeat the purpose of the rapid flux build-up in the brake magnet.

In Fig. 3 is shown an oscillograph record of capacitor-aided flux build-up and decay. The same electromagnet that was used in obtaining the curves of Fig. 1 was used here also. It is noted that operating time is reduced to one-half cycle (1/120 sec) by capacitor discharge as compared to 6 cycles ($\frac{1}{10}$ sec) for lamp-type over excitation and 19 cycles (about $\frac{1}{6}$ sec) for normal voltage. It should be further noted here that lamp-type over-excitation may be carried beyond this point by increasing the number of bulbs in series and raising the supply voltage. The results so obtained may be made to approach those produced by capacitor discharge. This, however, involves the disadvantage that the power consumed by the lamps becomes several times that required to operate the brake. The increase in operating speed obtainable with capacitor discharge varies with the inductance of the coil as reflected in magnet diameter. In converting from normal to capacitor-aided excitation, engagement speed improvement ranges from a factor of 20 for small (5 in.)

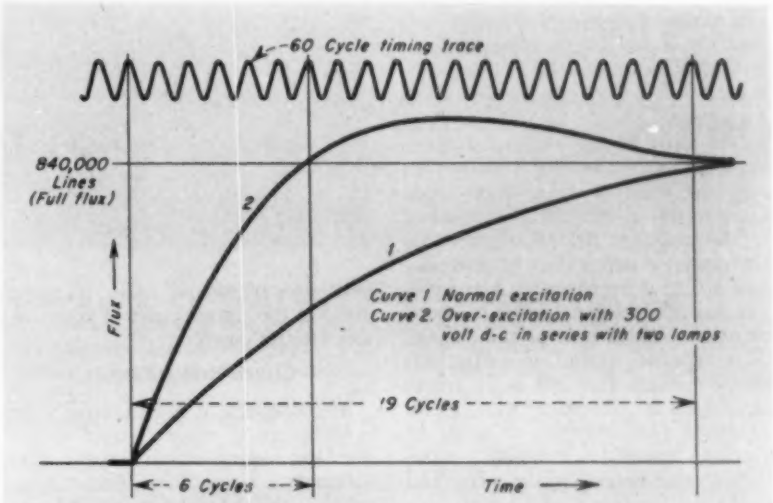


Fig. 1—Oscilloscope record of time required for brake operation under normal and over-excitation.

magnets to 37 for a large (15 in.) coil.

Further evidence of the effects of over-excitation on the speed of operation of electric brakes and clutches is presented in Table I. Speed of flux build-up and decay are given for 5 common sizes of electromagnets.

Table I—Speeds of Flux Build-up and Decay

A. Time Required for Build-up in seconds	Magnet Diameter				
	5 in.	8 in.	10 in.	12 in.	15 in.
Normal excitation	0.06	0.10	0.17	0.25	0.33
Lamp over-excitation	0.018	0.03	0.05	0.085	0.13
Capacitor-aided	0.003	0.005	0.007	0.008	0.009

B. Time Required for Decay in seconds	Magnet Diameter				
	5 in.	8 in.	10 in.	12 in.	15 in.
Normal decay	0.05	0.06	0.10	0.13	0.15
Capacitor-aided decay	0.003	0.005	0.007	0.008	0.009

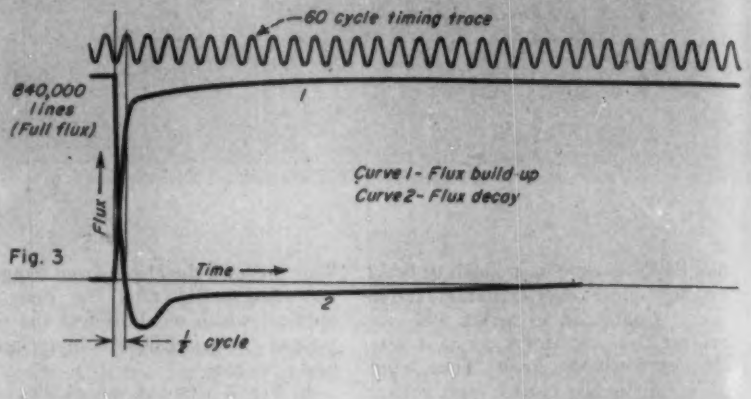


Fig. 3

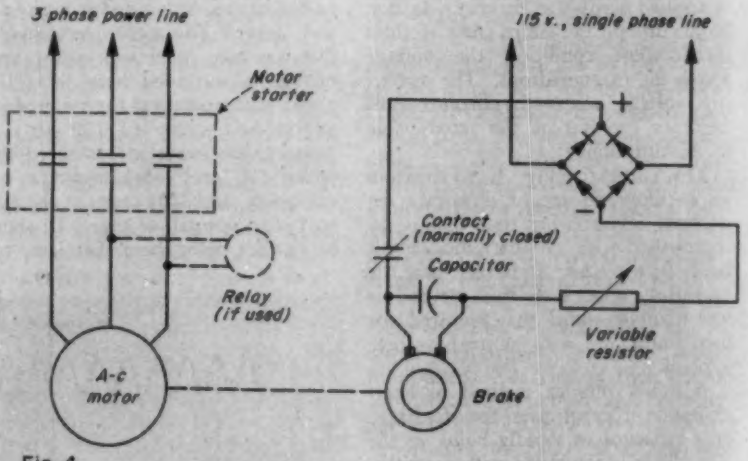


Fig. 4

Basic Brake Circuit

The diagram, Fig. 4, illustrates the elements of ordinary electric motor automatic braking. In this circuit, the brake is applied as soon as the motor is shut off.

The direct current, which is required for excitation of the brake coils, is supplied by a bank of metallic rectifiers. Alternating current is not used for the excitation of electric brakes and clutches for the following reasons: first, the continually varying current produces a lower developed torque that pulses through zero, causing unwanted slipping; and, second, iron losses are introduced, causing objectionable heating and lowered efficiency. A laminated steel magnet structure to reduce a-c iron losses would be expensive and not economical to manufacture. The 115 volt a-c line feeding the rectifiers is taken from the secondary of a step-down transformer fed from one phase of the main power line, unless this voltage is directly available. A full-wave bridge rectifier is used because of its high efficiency and comparative cheapness.

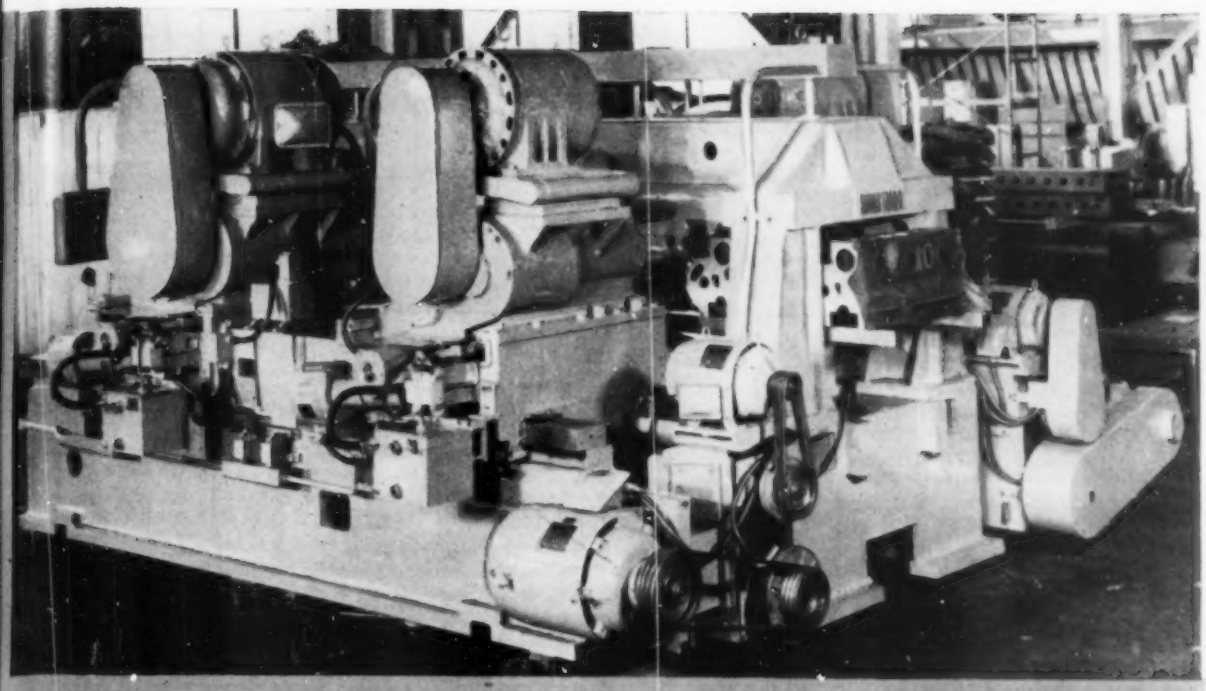
The normally closed contact that energizes the brake when the motor is deenergized, and vice-versa, may be either an auxiliary contact on the motor starter, or a relay contact. The relay coil in the latter case is connected in parallel with the motor winding. The resistor, shown in series with the brake, may be either a rheostat, or a fixed resistance of pre-determined size to limit the excitation current and thus regulate the braking torque applied to the load.

The capacitor is used to suppress sparking at the contacts caused by the inductive effect of the magnet. Upon breaking the circuit, the energy stored in the magnetic field is absorbed by the capacitor rather than in objectionable arcing at the contacts. The capacitor has the additional value of shortening the release time of the magnet. This type of control is particularly effective when frequent stops are to be made as compared with motor plugging (i.e., stopping a motor by current reversal). Plugging causes considerable heating in the motor and limits the frequency with which such stops can be made by standard induction motors. Friction braking usually involves a less expensive control for most sizes of motors. Also, plugging involves the consumption of considerable electric power.

Clutch-Brake Circuit

The diagram in Fig. 5 depicts the ordinary circuit elements used with a standard electric clutch-brake combination on a motor drive. Such combinations, which are widely used, are of value for applications such as those where frequent starts and stops are to be made or those involving rapid positioning of a tool. They are readily adapted for automatic operations.

In this particular application, the driving motor runs continuously and the clutch and brake start and stop the work load. Switching from clutch to brake is done with a relay as illustrated. With the motor running and the control switch opened, the relay contacts are in the position shown. Thus, the brake coil is energized and the load stationary. When the control switch is closed, the relay contacts are



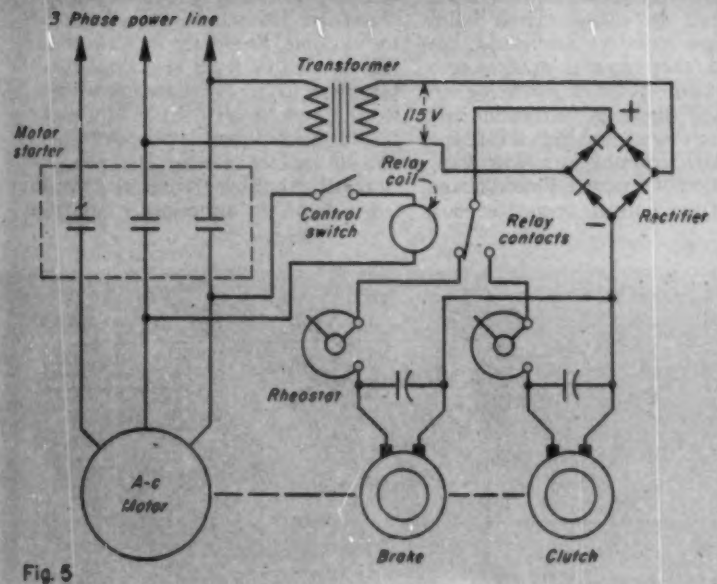


Fig. 5

Fig. 2—Drive motors of this Sundstrand Rigidmil are controlled by multiple electric brakes. Fast operation and low friction losses of electric brakes benefit designers of such machines, which are affected by the continuing trend toward higher speeds and more severe duty cycles.

Fig. 3—As shown by this oscillograph, operating time is reduced to ½ cycle (1/120 sec) by means of capacitor discharge.

Fig. 4—Basic brake circuit. Brake coil is energized from the main power line through a transformer and bank of rectifiers. When motor starter is opened, the brake relay is deenergized.

Fig. 5—Clutch-brake circuit. When this system is used, the motor runs continuously. The load is started and stopped by movement of the control switch.

thrown so that the brake is released and the clutch engaged. Since relay power is taken from the motor side of the motor starter, the brake is energized whenever the motor is shut down, regardless of the position of the control switch. The transformer, which is needed whenever the power line is greater than 115 v, supplies the rectifier that furnishes direct current to the brake and clutch magnets.

Capacitors are connected across the brake and clutch magnets to eliminate sparking at the relay contacts and also to assist the magnetic flux decay when the magnets are de-energized. The rheostats shown in the brake and clutch circuits are used for control of magnet operation, so that the starting or stopping torque may be regulated to the requirements of the drive.

Slip-Clutch Circuit

Shown in Fig. 6 is a method by which an electric clutch may be used in a slipping clutch application. This circuit provides speed control which is adjustable to fluctuations in the load. By means of either automatic or manual positioning of the variable rheostat, the transmitted torque is changed by varying the voltage drop across the magnet coil. The maximum magnetic force exerted by the coil must be kept below the force required to pull-in the clutch magnet completely. Thus, a fixed resistor is connected in series with the variable resistor and the magnet coil to control

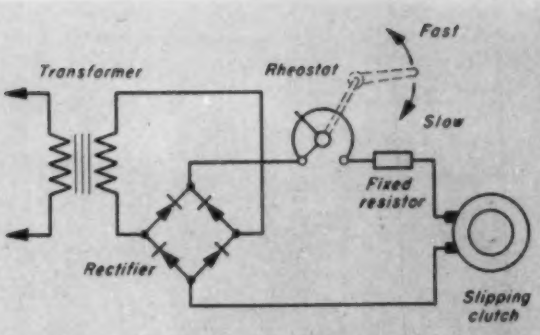


Fig. 6—Slip-clutch circuit. This system can be used to provide adjustable speeds for a constant load or constant speed for a varying load. Resistor limits current so clutch cannot pull-in completely, regardless of rheostat setting.

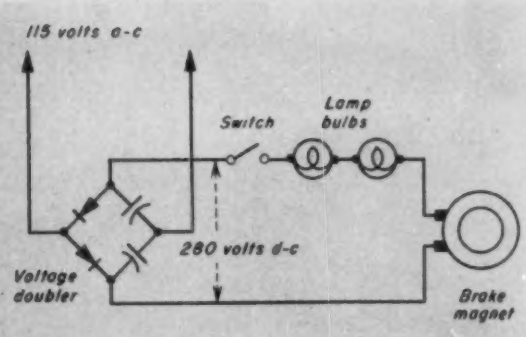


Fig. 7—Over-excitation circuit. A high voltage is initially applied to the magnet coil for fast operation. As soon as the lamp filaments heat up and their resistance increases, the coil voltage is automatically reduced to normal.

the maximum voltage drop across the magnet. The clutch will slip at all values of load.

The transmitted torque is inversely proportional to the amount of slip. By changing the value of the exciting current, and thereby the amount of slip, speed of the machine can be kept constant with a varying load or can be adjusted between wide limits with a constant load.

The heating of a slip-clutch during continuous operation of a load is, of course, greater than the heating that would occur in a standard clutch that was required to start the same load frequently. Thus, larger magnet and armature structures are usually incorporated in electric clutches for slip-type applications to effectively dissipate the heat. Conversely, the coil current in a slipping clutch is less than the coil current in a fully engaged clutch. If service is to be severe, the slip-clutch may be of entirely special design—with oversize construction, smaller gage wire and high temperature friction linings.

Over-excitation Circuit

If it is desired to effect a more rapid brake application than can be obtained by energizing the coil with full rated voltage, the method of over-excitation illustrated in Fig. 7 can be employed. This circuit increases the speed of brake application by approximately three times, and the improvement in braking is considerable. In the layout shown, a full wave voltage doubler bridge circuit boosts the voltage from its a-c value to a much higher direct current voltage. This voltage doubler consists of two rectifier units and two large capacitors connected in the bridge circuit.

By this method, the increase in d-c voltage over the a-c value will be approximately 2½ times, depending upon the value of the capacitor units used. This higher voltage value gives the over-excitation effect when applied to the brake in series with two ordinary 115 v. lamp bulbs which are matched to the circuit. These bulbs have a low resistance when cold, but as soon as they come to incandescence the resistance becomes much higher. As a result, the high voltage initially applied to the magnet to build up the flux rapidly, drops to the rated voltage in a fraction of a second. Rated voltage produces the normal amount of flux that is required to transmit the torque rating of the brake.

The rate of flux build up closely matches the speed at which the lamps come up to full incandescence. Thus, a fairly simple circuit provides a considerably shortened rate for brake applications. This scheme could be used, for example, to rapidly stop a cutting tool where the over travel must be kept low to prevent spoilage of the work. If the brake is to be left energized for a considerable period of time, this circuit can be refined to provide automatic shift-over from the series lamp circuit to an ordinary straight

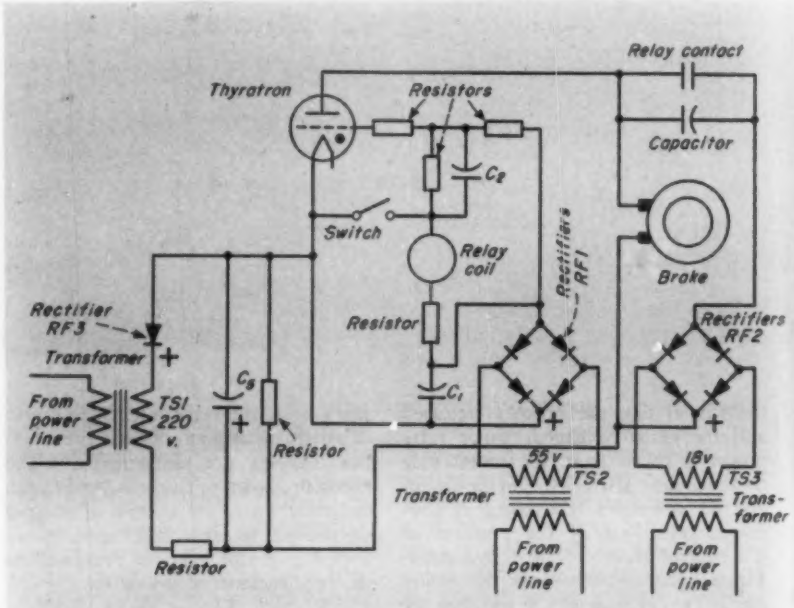


Fig. 8—Capacitor-aided circuit. When the switch is closed, the thyratron tube conducts current for a short period of time. The conducting thyratron completes a circuit between the capacitor C5 and the brake coil.

excitation circuit for holding. This shift-over can be made to operate as soon as the magnet is at full excitation, thus avoiding the power waste of the lighted lamps.

Capacitor-aided Circuit

The diagram in Fig. 8 illustrates the operation of the capacitor-aided method for extremely rapid flux build-up in a brake magnet. The thyratron tube serves as the switching element by which the large capacity condenser C5 is discharged through the brake magnet. This capacitor is charged from the 220 volt secondary winding TS1 of the power transformer through the adjacent rectifier RF3. Since the normal rated voltage of the magnet used with this circuit is 10 volts, a high magnitude of over-excitation can be applied to the magnet coil for only a short period. The designer is also required to match the size of capacitor C5 to the size of the magnet coil so that the energy stored in the capacitor will be sufficient to bring the flux in the magnet up to its full value. Following the discharge of the capacitor, another portion of the circuit applies rated voltage to maintain the magnet excitation.

In operation, the switch is closed when it is wanted to brake the load. Closing the switch brings the grid of the thyratron to cathode potential. The tube fires (current is conducted from cathode to plate). The conducting thyratron completes a circuit that allows the charge on capacitor C5 to discharge through the magnet coil. This discharge occurs within about ½ cycle (or 1/120 sec., referring to the 60 cycle a-c supply voltage).

The closing of the switch causes the capacitor C2 to begin charging from the rectifiers RF1. The charge on this capacitor puts a negative potential on the grid of the thyratron, preventing the tube from conducting further. The relay coil is also energized from rectifiers RF1 when the switch is closed. The contacts of this relay complete a circuit to the magnet coil from the rectifier stack RF2. This circuit applies rated voltage to the magnet coil, keeping the coil at normal excitation after the initial capacitor surge.

This entire operation occurs in an extremely short period of time. Full flux is built up in the brake magnet in a few milliseconds. Because of the speed of operation, this circuit would be ineffective if mechanical linkages were employed to set the brake. The over-excitation period would be completed long before play in the linkages could be taken up. But with disk-type brakes, the linings are engaged with the shoe the instant the magnet is energized. This diagram, Fig. 9, shows the application of electronic control involving capacitor-aided flux build-up and decay to a clutch-brake combination. In common with all clutch-brake combinations, this system does not shut down the driving motor, which continues rotating. The load is connected to and disconnected from the drive as required. The brake operating portion of this circuit is the same as that shown in Fig. 8, and its action is the same as that described under that portion of the article. However, a clutch operating portion has been added.

The clutch operating circuit is similar to that used with the brake, but with one notable difference. The discharge from capacitor C6 through the clutch magnet is of opposite polarity from the normal energizing current supplied by rectifier RF3. Therefore, the flux in the clutch magnet which has been maintained by RF3 is cancelled by the capacitor discharge.

Decay of clutch magnet flux occurs when the second thyratron tube is caused to conduct by the closing of contact R3. It is seen that all the switching is accomplished by means of this one relay. Relay contacts R1 and R2 switch the normal exciting power supplied by rectifier RF3 from the clutch to the brake. Contact R3 operates the second thyratron tube in the same manner as the switch triggers the first thyratron, described under Fig. 8. In this manner the brake is energized and the clutch is de-energized at practically the same instant. Any objectional over-lapping effect is eliminated. When the switch is opened, contact R1 opens, deenergizing the brake and contact R2 closes to operate the clutch in the normal manner.

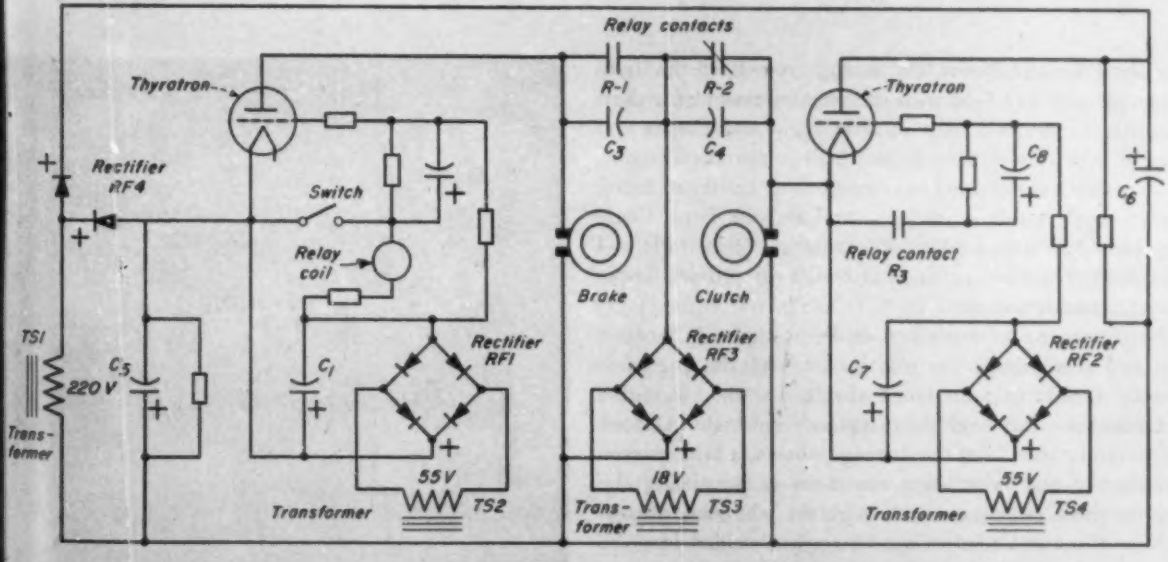


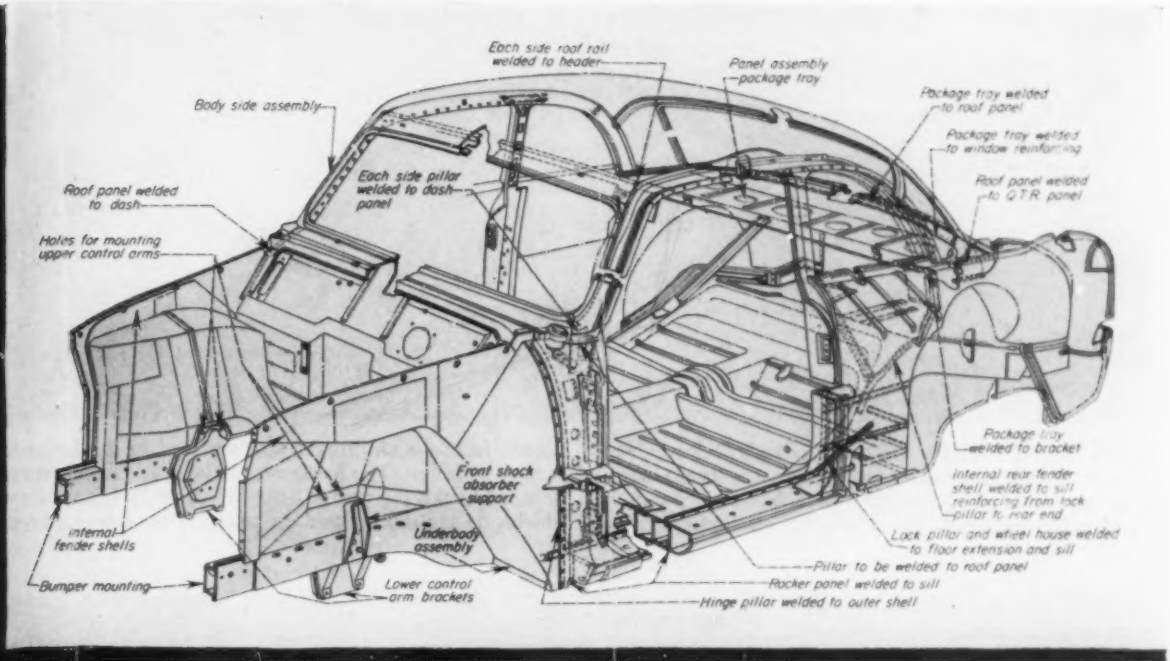
Fig. 9—Capacitor-aided clutch-brake circuit. Thyratron tubes are incorporated in both brake and clutch control circuits. Two capacitors discharge simultaneously into coils of both magnets. Brake and clutch operate without overlapping.

Willys Lightweight Car Features Integral

Willys Overland Motor, Inc. recently re-entered the lightweight pleasure car field with the announcement of a short wheelbase automobile with integral body and chassis and powered with a six-cylinder F-head high compression engine. The car, which is designed to compete with small cars being manufactured in this country, as well as with Ford, Chevrolet, and Plymouth, is only 180⅞ in. long., 72 in. wide and 60 in. high. The 61 in. wide seats of the car provide ample passenger accommodation.

The passenger compartment is cradled completely between front and rear wheels for riding ease, and the engine is mounted directly over the front wheels. The road is visible 10 ft from the car through the two piece windshield. All four fenders can be seen from the driving position, a large curved rear window and protruding rear fenders permitting the driver to check car clearance through the rear view mirror.

Box sections and reinforcing flanges are welded into the body to make the body and structural chassis members a unit construction. The inside shells of the front fenders are welded to the body and carried forward as part of the cowl.

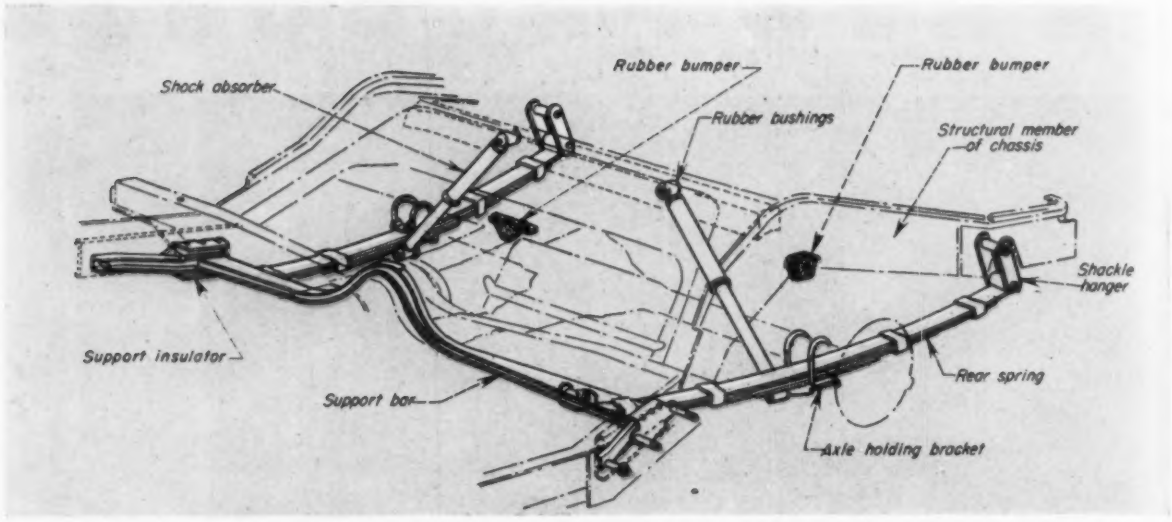

Each side roof rail welded to header
Panel assembly—package tray
Body side assembly
Package tray welded to roof panel
Package tray welded to window reinforcing
Roof panel welded to dash
Each side pillar welded to dash panel
Roof panel welded to Q.T.R. panel
Holes for mounting upper control arms
Package tray welded to bracket
Front shock absorber support
Internal rear fender shell welded to sill reinforcing from lock pillar to rear end
Lock pillar and wheel house welded to floor extension and sill
Internal fender shells
Underbody assembly
Pillar to be welded to roof panel
Bumper mounting
Lower control arm brackets
Rocker panel welded to sill
Hinge pillar welded to outer shell

Body Design and F Head Engine

The outside fenders are welded to the inside shells and together they form box-like extensions of the body in which the long coil springs of the front suspension system are anchored.

The points of support of the suspension springs are high above the center of gravity of the car to maintain a low stress variation over the deflection range of the springs and to stabilize the car sufficiently so that an anti-roll device is not required. To insulate the car from road resonance, both ends of the springs are mounted on rubber silencers. The full displacement shock absorbers and rear springs, are rubber mounted. The hydraulic brakes are standard 9 x 2 Bendix floating type, and the master cylinder is mounted to act directly with the peddle motion.

The outstanding performance is due to the high power to weight ratio. The F-head engine, mounted on three rubber lined supports, develops 90 hp. at 4,400 rpm with a $5\frac{1}{8}$ in. bore, $3\frac{1}{2}$ in. stroke and a 7.6 to 1 compression ratio. Premium gas is not necessary because the 2 in. intake valves provide easy breathing and help maintain high volumetric efficiency.

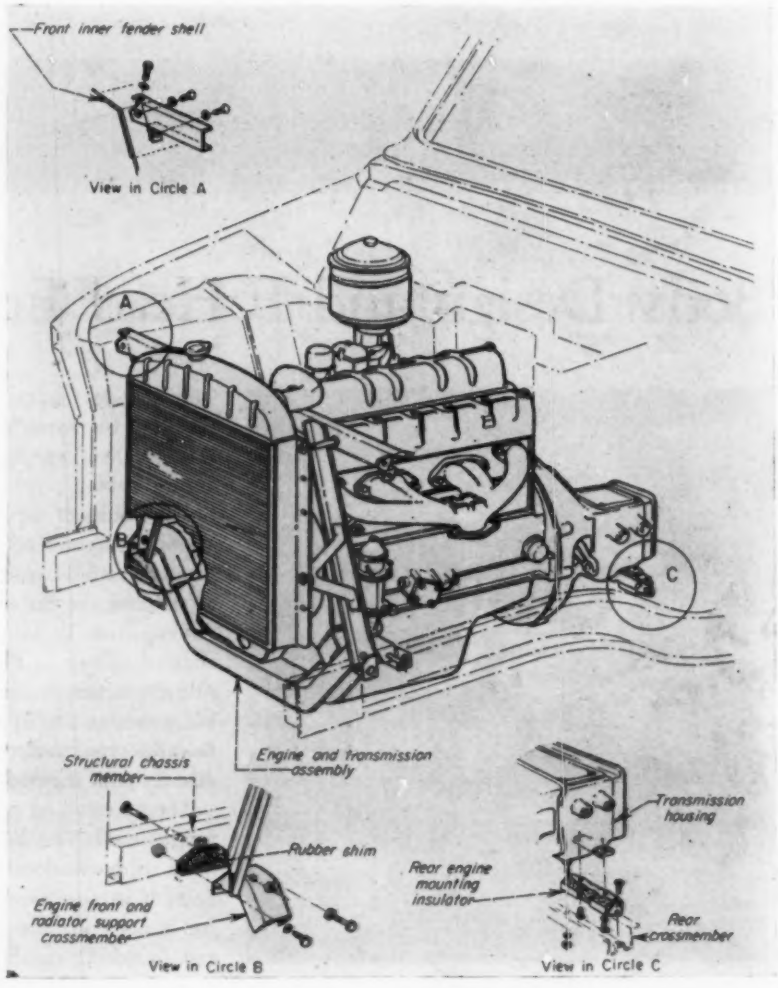


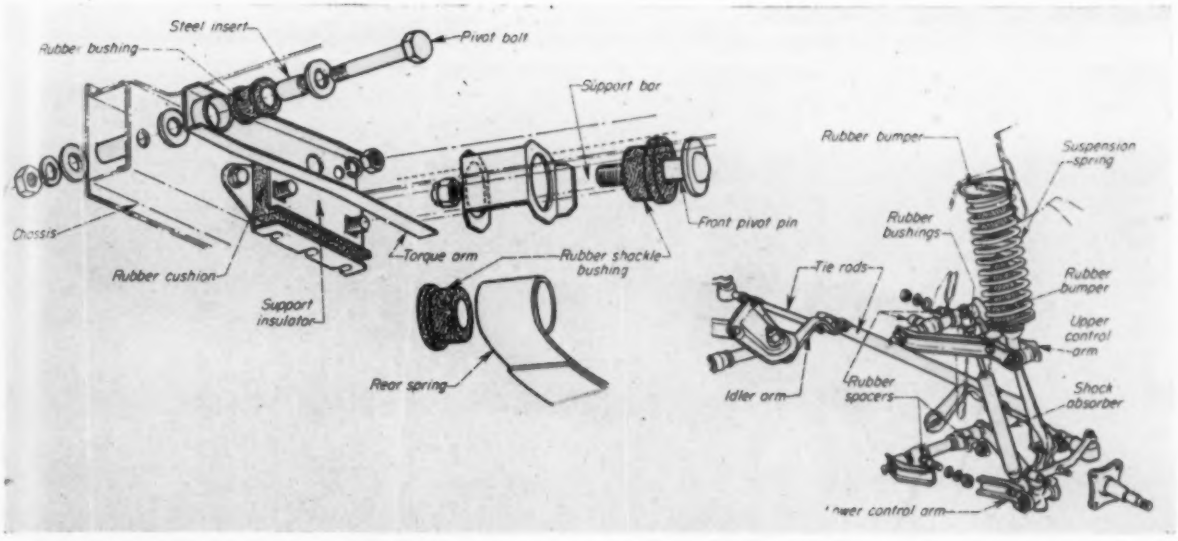
UNDERSLUNG REAR SPRINGS contain 7 leaves each and with 3 front seat and 3 rear seat passengers maintain a distance of 5 in. between the rear axle housing and the chassis. The front eye and rear shackle bearings are rubber lined. Rear shackle hangers are mounted to the body on rubber bushings. The loop-ends of the shock absorbers are separated from their pivot bolts by rubber bushings. Dust shields on the shock absorbers protect them from damage.

ENGINE and transmission assembly is mounted at three points. The front engine and radiator support member is bolted to the chassis through rubber shims. The transmission rests on a rubber lined channel bolted to the chassis. In designing the engine-transmission assembly its fundamental frequency was kept below the engine idling speed to prevent resonant vibrations from being transmitted from the engine to the car while it is running.

EXHAUST SYSTEM insulation. Exhaust gas vibrations are kept from entering the car body by mounting all parts of the exhaust system to the insulated engine or on insulated hangers. The exhaust pipe is fastened to the rubber mounted engine. The muffler assembly is supported at one end by the exhaust pipe and the other end by the tail pipe. One hanger of the tail pipe extends from a rubber lined under body bracket that is bolted directly to the chassis and the other hanger is suspended from the rear body cross member. The muffler has no direct contact with the car body.

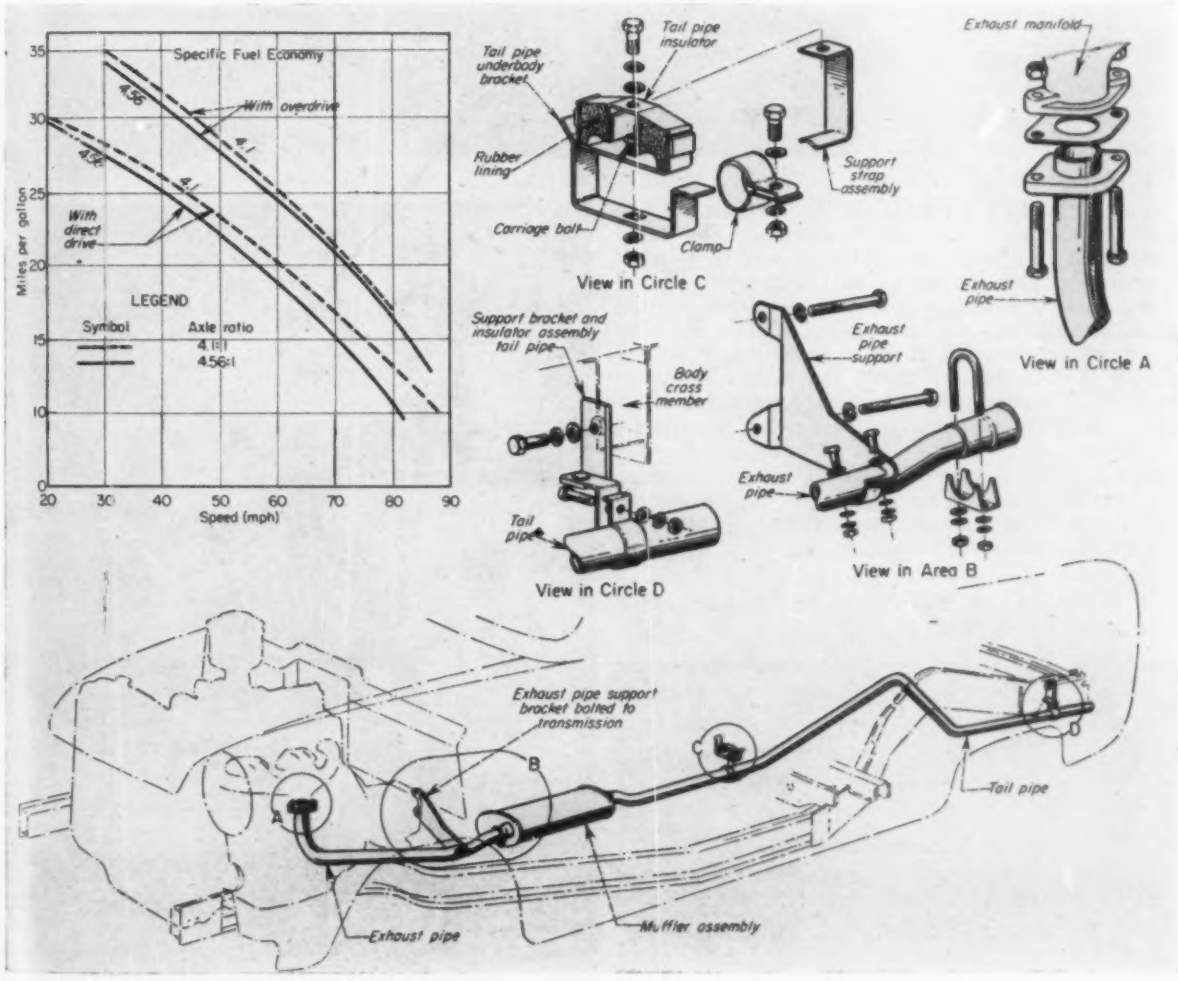
THE CURVES indicate car performance with various axle ratio and overdrive combinations. The 4.1 to 1 drive is standard in cars without overdrive and the 4.5 to 1 drive ratio is standard in cars with overdrive.



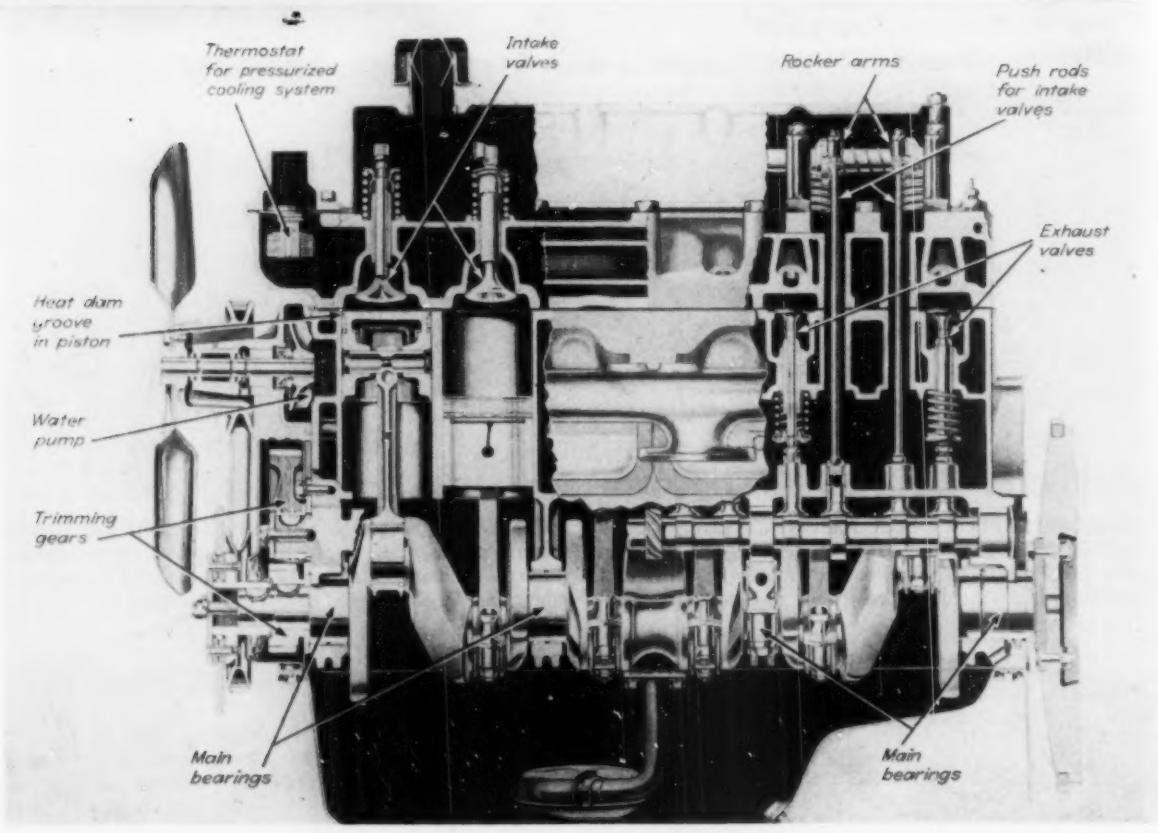


THE REAR SUPPORT BAR ASSEMBLY pivots around rubber insulated anchor bolts in the chassis and rides in rubber lined channels bolted to the frame. Front end of each spring is mounted on two rubber bushings.

FRONT SUSPENSION assembly. By mounting all the moving members of the suspension system to the chassis through rubber insulators the car is isolated from road vibration. The springs have a free length of 17.5 in.



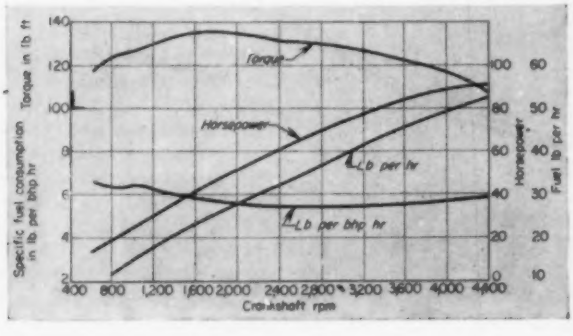
1952 Automobiles

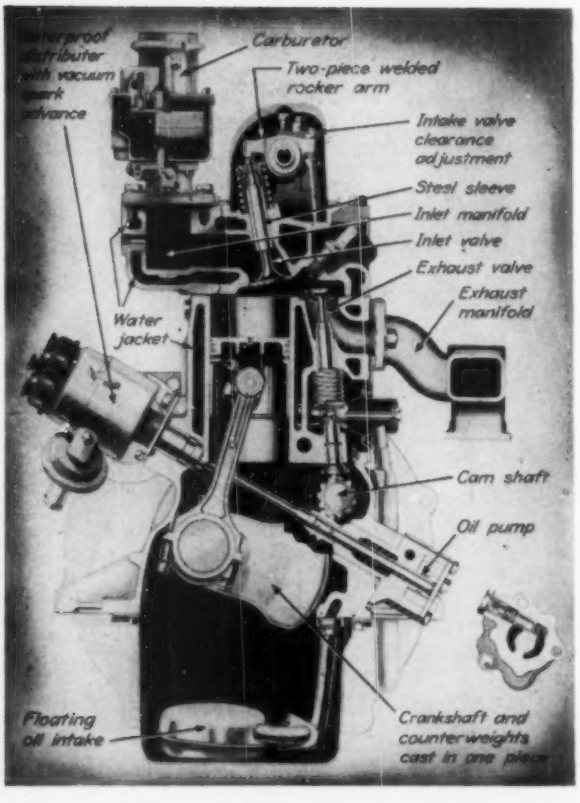


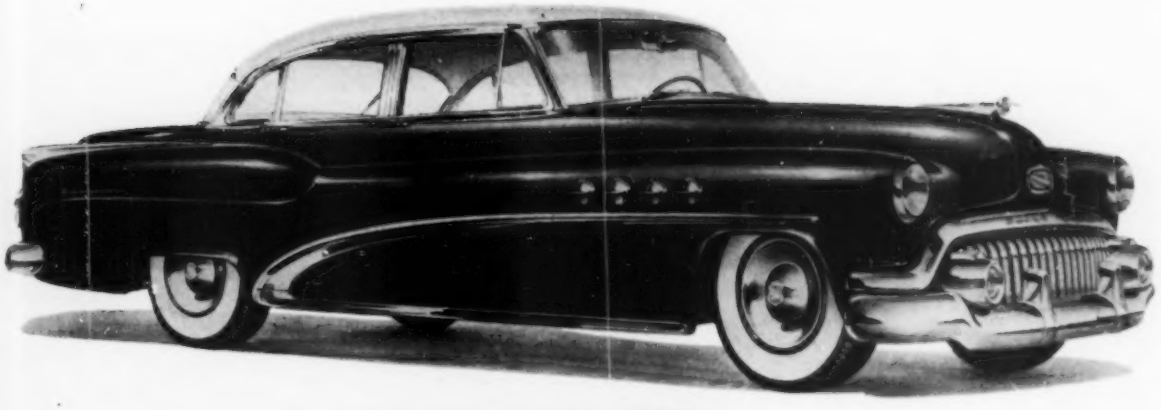
THE 6-CYLINDER F-HEAD ENGINE weighs 548.5 lb with the clutch and transmission included. The intake manifold is an integral part of the cylinder head and is kept at a constant temperature of 170 to 175 F by the engine coolant. The 2 in. inlet valve is placed near the center line of the cylinder. The spark plugs are close as possible to the center of the incoming charge and are directly over the exhaust valves. The exhaust valves are made of 2112 alloy steel and are equipped with positive rotators to prevent burning. The valves ride in steel sleeves.

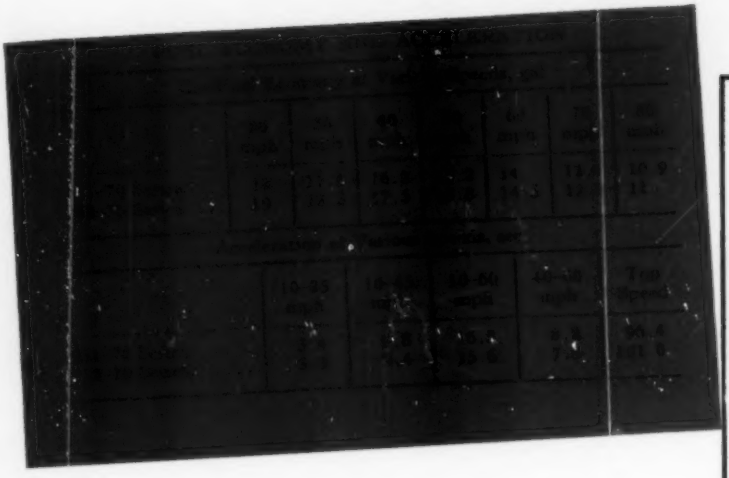
EACH PISTON is equipped with two compression rings and one oil ring. The top compression ring is chrome plated and the oil control ring is backed up by a flat watch spring. Wrist pins and cylinders are splash lubricated.

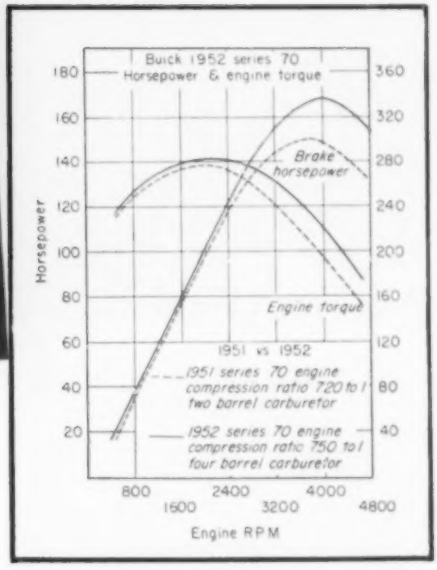
ENGINE RUNS most efficiently in the 2,800 rpm range with a fuel consumption of about 27.6 lb per bhp-hr.











Hydraulic Steering and More Power in '52 Buick

Mechanical and style changes in the 1952 Buick Roadmaster include power steering, increased engine output, a larger luggage compartment and trim revisions.

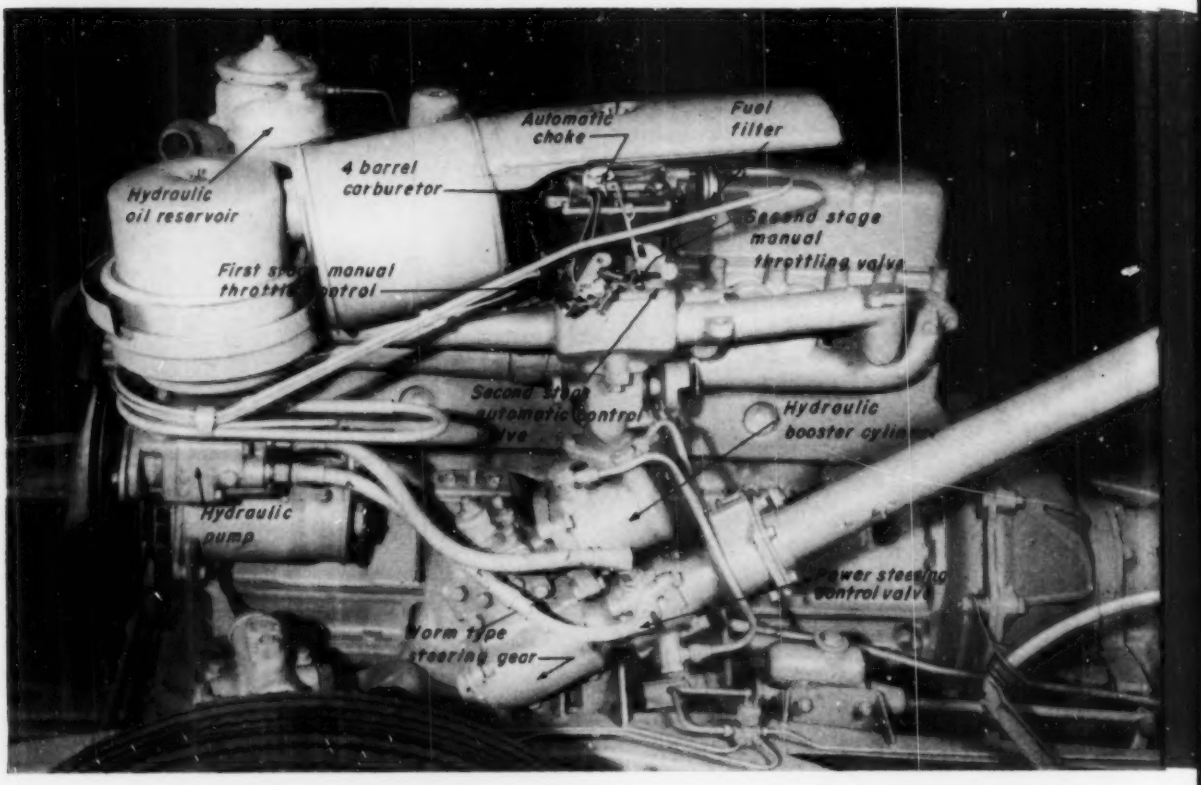
The mechanical power steering gear is combined with a hydraulic booster that will assist the driver in turning the wheel when an effort of more than 4 lb is required. All normal steering can be accomplished with a maximum effort of 9 lb, and normal feel of steering is retained in the gear. Hydraulic power is supplied by a belt-driven pump on the engine. In case of power failure, the gear will function in the conventional manner.

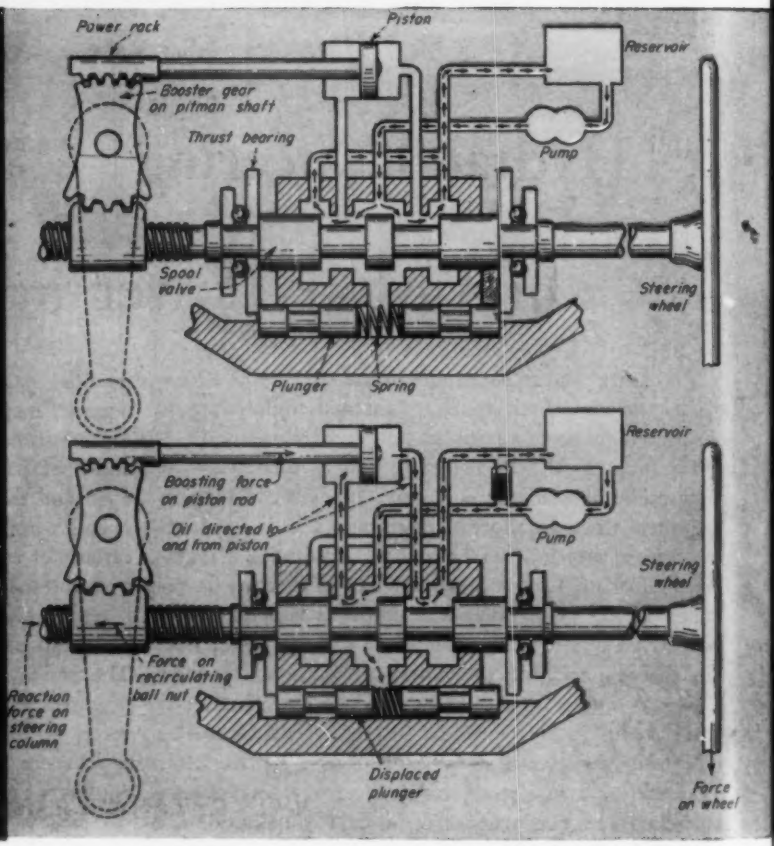
Engine output on the Roadmaster has been increased from 152 to 170 hp. by using a 4-barrel carburetor and by increasing the compression ratio from 7.2-1 to 7.5-1. The carburetor consists of two dual carburetors mounted back to back. The primary carburetor contains all the essential parts normally found in a conventional carburetor, including an automatic choke. The secondary carburetor has an idle circuit and a main metering circuit and operates only when the throttle is more than half open and the engine requirements are great enough to open a counter-balanced auxiliary value. The use of this carburetor has resulted in higher volumetric efficiency over the entire speed range of the engine.

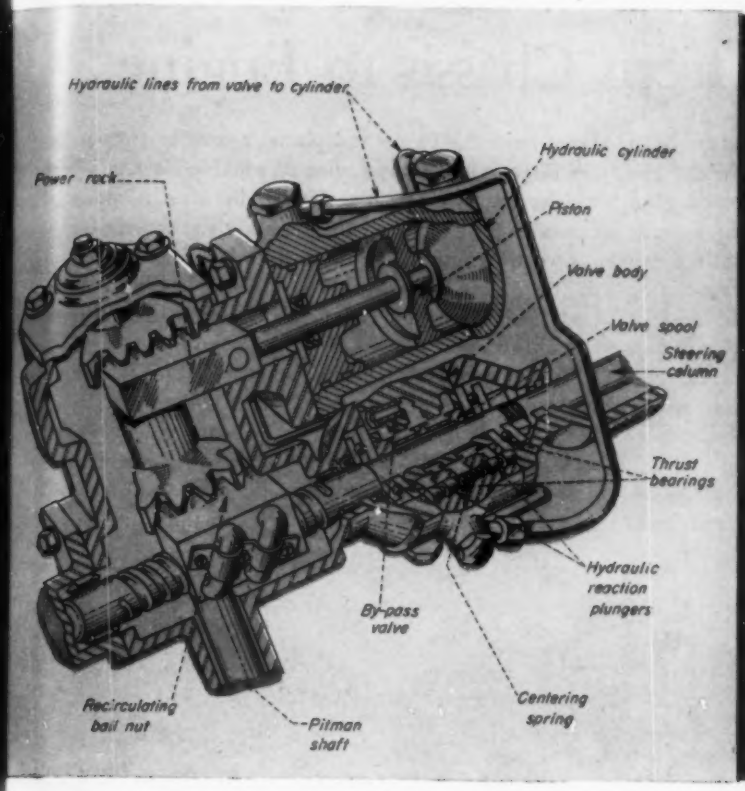
Appearance changes have been made in all models. The radiator grille has 17 full bars and 2 quarter bars. The trunk cover on the Roadmaster and Super series has been redesigned with a high arc contour to provide more room in the luggage compartment and improve car appearance. A wrap around bumper guard is standard equipment only on the Roadmaster.

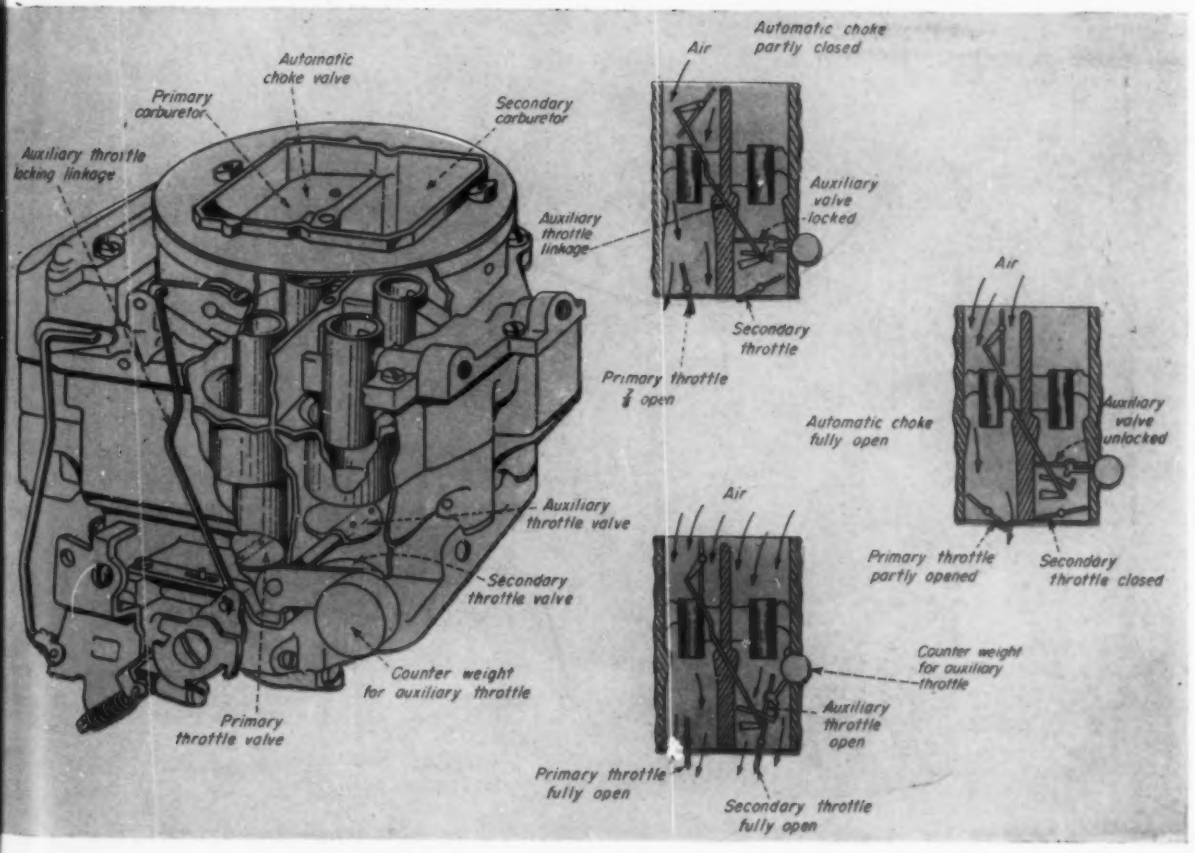
(Continued on next page)

1952 Automobiles






Hydraulic lines from valve to cylinder
Hydraulic cylinder
Power rack
Piston
Valve body
Valve spool
Steering column
Thrust bearings
Hydraulic reaction plungers
By-pass valve
Centering spring
Recirculating ball nut
Pitman shaft


Automatic choke valve
Primary carburetor
Secondary carburetor
Auxiliary throttle locking linkage
Auxiliary throttle linkage
Auxiliary throttle valve
Secondary throttle valve
Counter weight for auxiliary throttle
Primary throttle valve
Air
Automatic choke partly closed
Auxiliary valve locked
Secondary throttle
Primary throttle ⅛ open
Air
Automatic choke fully open
Auxiliary valve unlocked
Primary throttle partly opened
Secondary throttle closed
Air
Counter weight for auxiliary throttle
Auxiliary throttle open
Primary throttle fully open
Secondary throttle fully open

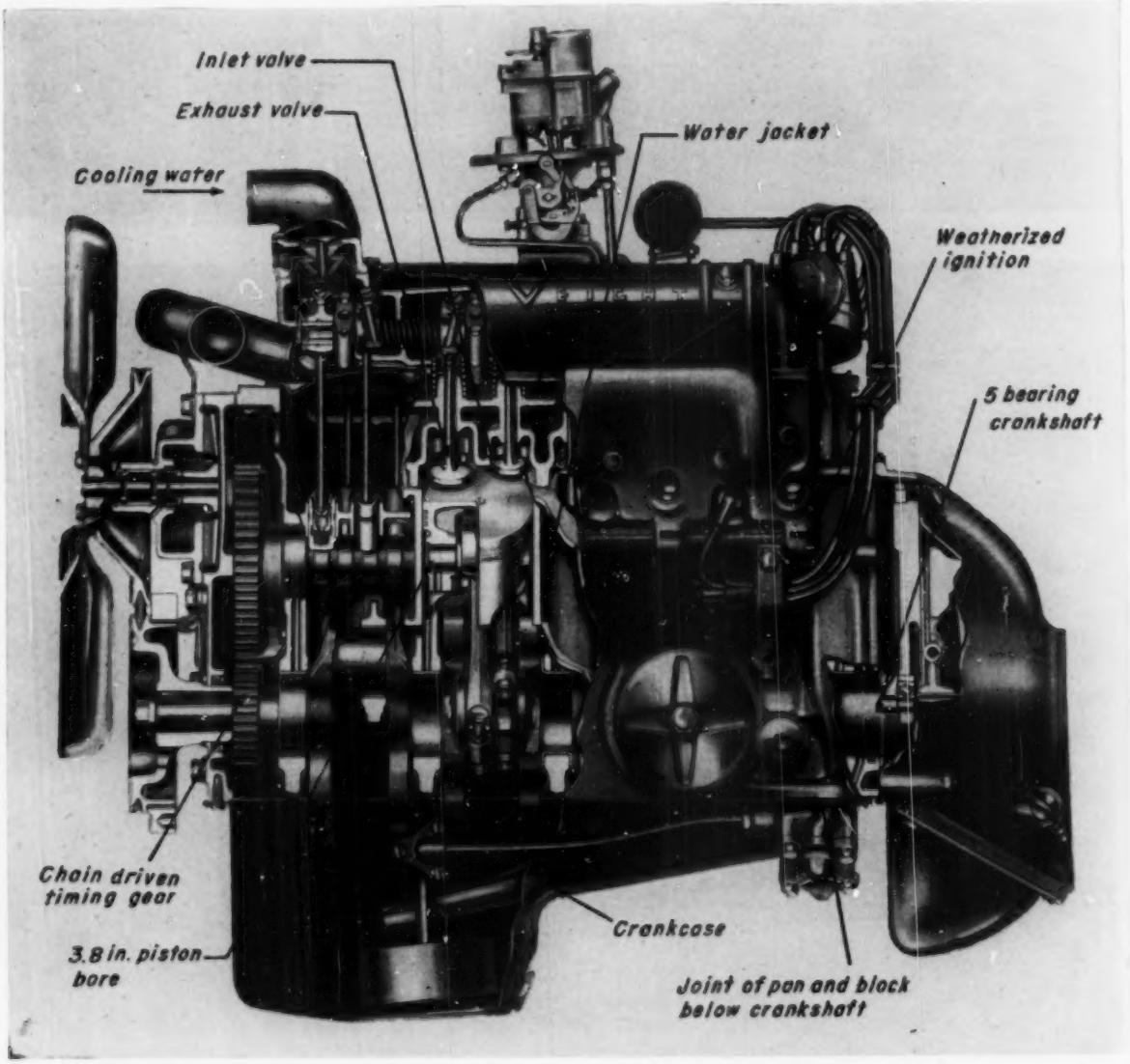
Lincoln New from Chassis to Engine

Seldom in the history of the automotive industry has a car been so radically changed as the 1952 Lincoln. The body is completely new, with greatly increased glass area, a shorter hood line, and a protruding luggage compartment that is reminiscent of the lines on the pre-war, low slung Continental. The 160 hp engine is an overhead valve V-eight featuring a large bore-stroke ratio, high compression ratio, rigid intermediate bulkheading, and hydraulic valve lifters. And Lincoln engineers believe that the front wheel suspension system which substitutes ball and socket action for the conventional kingpin joint, is a major improvement.

To keep a low silhouette and obtain better engine mounting, body designers removed the large front cross beam from the frame and placed a tubular cross member directly under the engine to provide support where weight is at a maximum. The engine thus is mounted closer to the road, and the frame is strengthened.

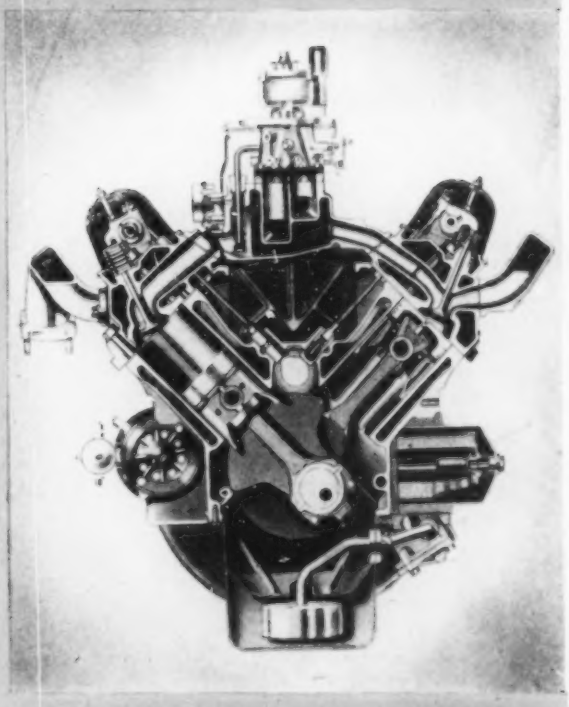
Overall length of the car is 8 in. less than the length of the '51 model, while the wheelbase has been shortened 2 in. to make 123 in. between wheel centers. Weight has been cut by about 400 pounds.

The objective of Lincoln engineers was a very high performance automobile with the streamlining and visibility that is demanded by the passenger car buyer of today. Roadability of the car is excellent, power plant design sound, and the styling both inside and out will put other luxury car manufacturers on their mettle.



(ABOVE) Lincoln engineers have standardized on the Cosmopolitan series, which is available in a two- or four-door sedan, two hardtops, and a convertible. Note the increased area and height of the windows and the smaller front columns, both of which provide better visibility. Extension of the luggage compartment and shortening of the hood line have resulted from the more compact overhead valve V-8. As on the entire Ford line, gasoline filler neck is hidden behind the spring held license bracket.

(LEFT) Advantage of the overhead valve design is more compact powerplant and a high compression ratio—7.5:1—with less heat rejection. Pressure of the cooling system is 13 psi, compared with 7 psi in the former engine; a thermostatically controlled by-pass valve allows the engine to come up quickly to the most efficient operating temperature range in cold weather. The cylinder block is heavily reinforced with intermediate bulkheads not shown here.



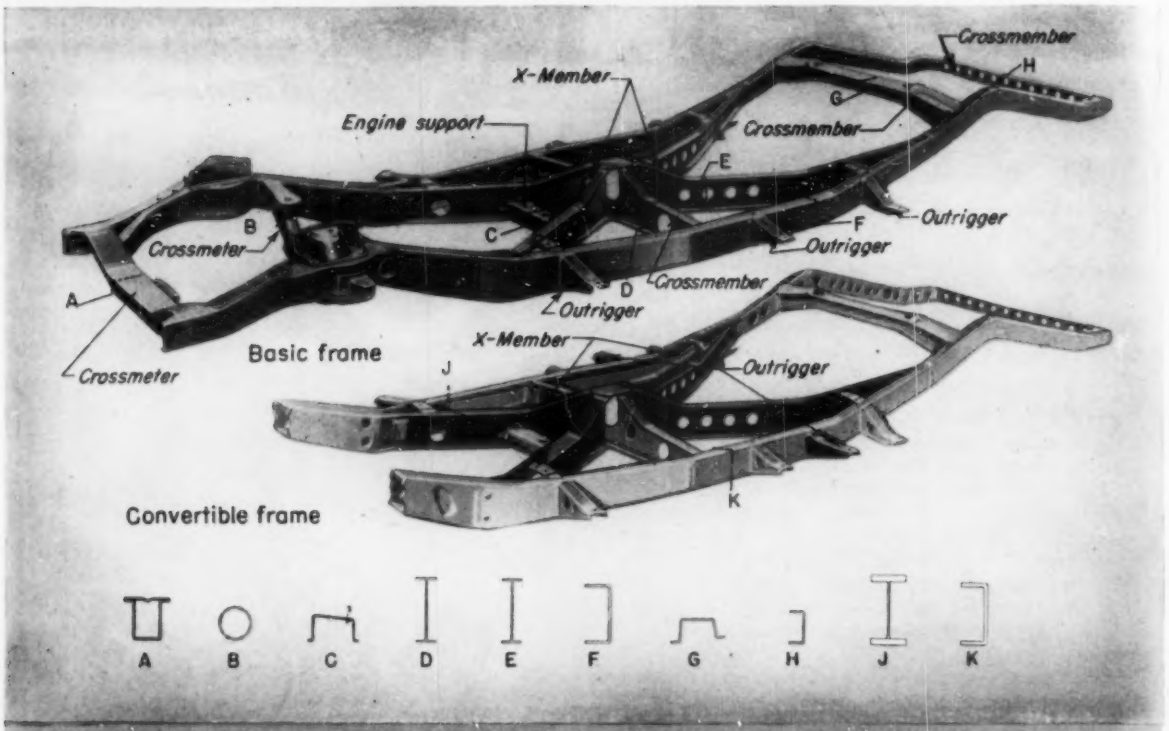
BODY DIMENSIONS
FOUR DOOR SEDAN

EXTERIOR	
Wheel Base	123.0
Overall length over Guards	214.1
Tread at Ground — Front	58.5
Rear	58.5
Max. Overall Width Includes Bumpers or Moldings	77.5
Windshield Max. Glass* Width	56.0
Backlight Max. Glass* Width	58.8
Overall height at Curb	64.2
INTERIOR	
Shoulder Room — Front	57.5
Rear	57.2
Hip Room — Front	62.5
Rear	62.1
Head Room — Front	36.4
Rear	34.7
Seat Height — Front	12.5
Rear	12.6

*Exposed Glass

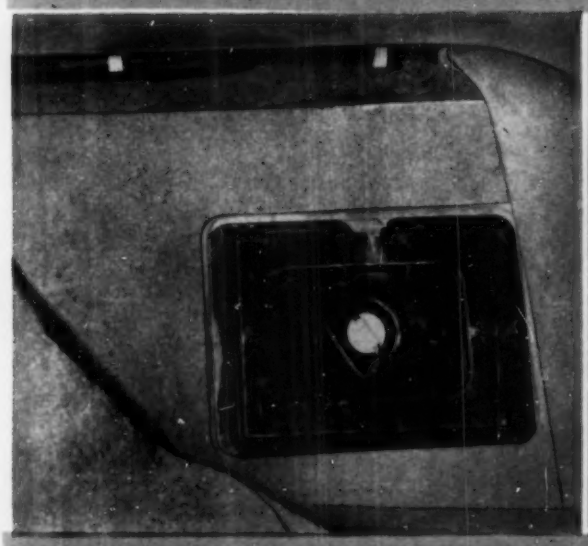
THE POWERPLANT develops 160 hp at 3,900 rpm, with a maximum engine torque of 284 ft-lb. The bore stroke ratio of 3.8 in. by 3.5 in. results in a relatively low piston velocity and small frictional hp losses; total piston displacement is 317 cu in. The single camshaft, full flow oil filter, slipper-type pistons, and hydraulic valve lifters are apparent in the cross-section.

A single mounting bolt holds the oil filter to a special mounting boss cast on the cylinder block. The engine has five main bearings to support the crank shaft which is totally enclosed in the block. The oil pan bolts on to the cast block in such a position that it can be removed from the bottom of the car with the engine still in place. Because of its rigid design, the engine can be easily converted to industrial use.

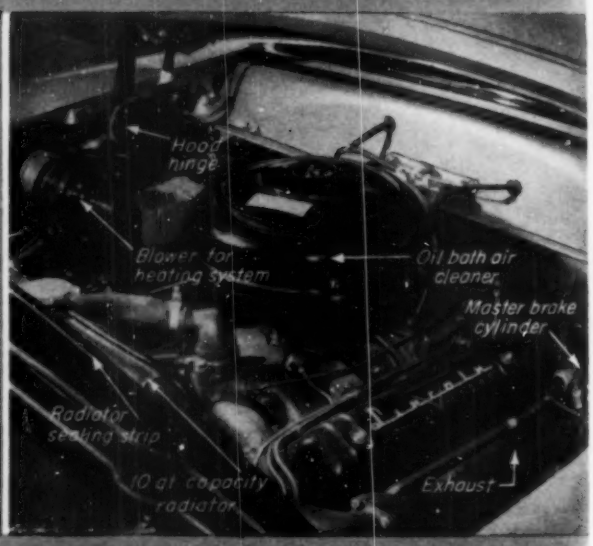


SEDAN and convertible frames. Both are conventional box types reinforced by an x-member, and the main cross member at the front was moved forward and a tubular cross member slung under the engine to provide support and torsional resistance. The channel sections, which are tied to the x-member also provide excellent torsional resistance, while the I-beam provides good resistance to bending. A capping strip is welded on the channel members for the convertible and hard top frame; this represents the only major difference between the two.

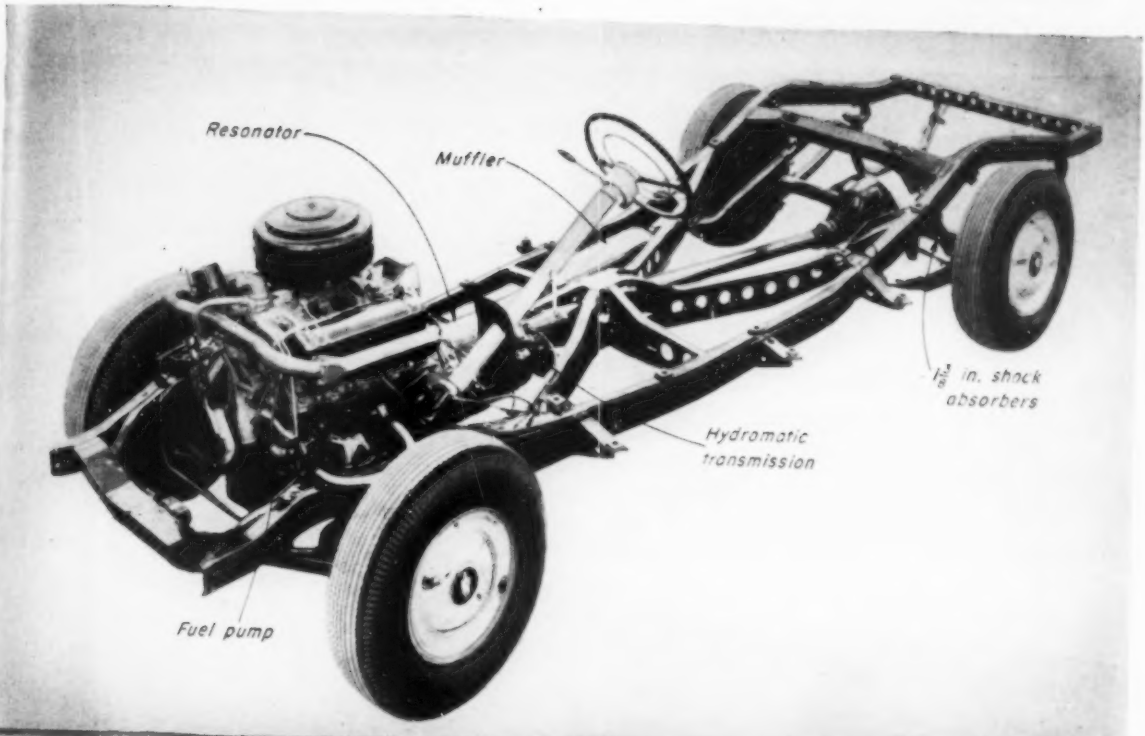
Extra outriggers have been welded to the convertable frame to provide a more rigid mounting for the lighter body. Both rivited and welded construction is used.



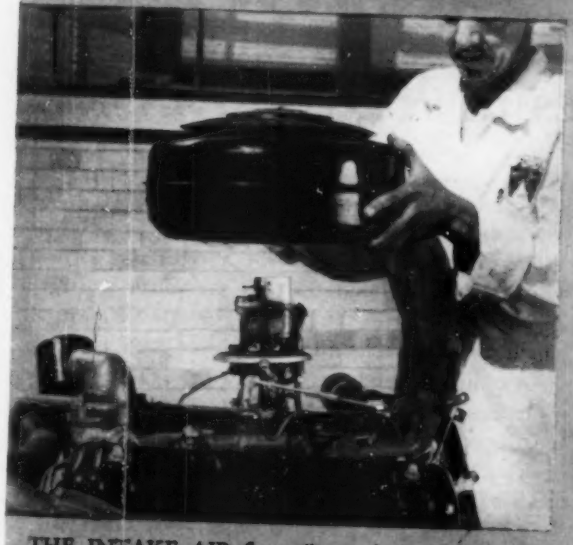
BECAUSE OF the compact engine mounting, space under the hood is at a premium. The battery therefore is mounted behind the front fire wall, under the toe board. The master brake cylinder is opposite the brake pedal on the engine side of the fire wall.



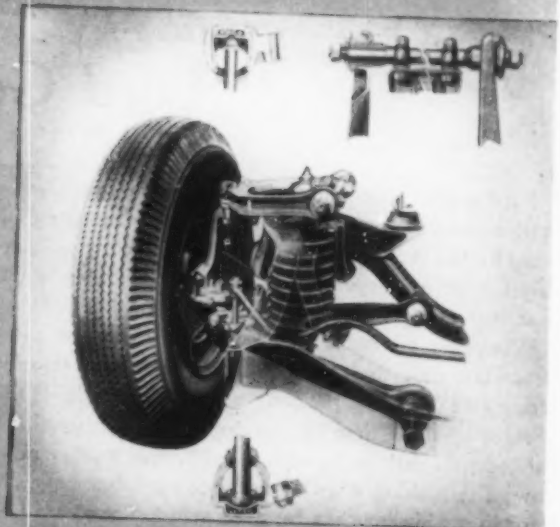
DESIGNING the oil bath air cleaner to form the outer shell of the carburetor accomplished several things: (1) there is a considerable saving in metal, there being no die case cover required (2) the design is more compact and (3) hood height is lower.



CHASSIS DETAILS for the four-door sedan. The steering linkage is under the oil pan, and the fuel pump is mounted on the lower right hand side of the engine where it runs 20 F cooler. Note how the engine nestles between the side frames, how the drive shaft runs through the x-member of the frame, and how the problem of the cross member interfering with the muffler was solved by using a resonator to knock out the major resonance and a smaller muffler to take out remaining noise. The rear suspension is supplemented by two rubber mounted bumpers under the side rails at the front of the leaf springs to obtain a variable rate spring under bad conditions and to prevent breakage under maximum stress conditions.



THE INTAKE AIR flows "around the float bowl keep's the fuel in the carburetor cool and helps prevent vapor locks. The automatic choke is divorced from the carburetor and is mounted on the manifold, where it can register truer engine temperatures.



NEW FRONT END suspension system. Kingpin has been eliminated, the relative posision of ball and socket joints providing kingpin action. Anti-friction thrust bearings are used and Belleville springs control friction and reduce vibration.

Ford Goes to Valve Overhead

Ford is after first place, production wise, in the automotive industry. Ford also is looking ahead to the time when higher octane fuels will make possible higher compression ratios, more efficient engines. And this is the year that Ford is really doing something about it.

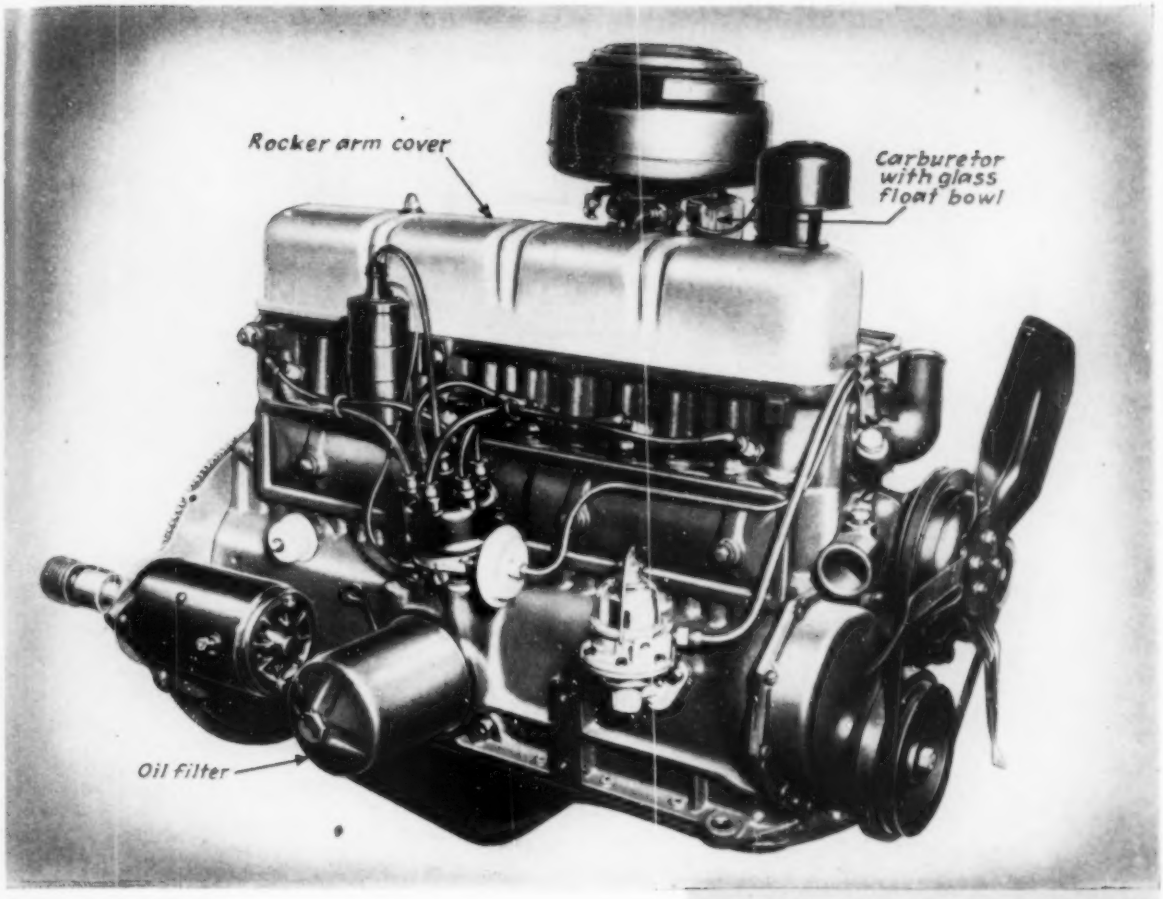
What they are doing is (1) introducing a new overhead valve six-cylinder engine with a higher horsepower rating (see table); (2) making temporary changes in the V-eight to allow time for development of an overhead valve design that can be introduced 2, 3 or 4 years from now; (3) making a major body change that puts the Ford in the big car class from the standpoint of appearance but keeps the basic price the same.

The 6-cylinder engine has been designed to match the speed and torque characteristics of the Fordomatic drive. Friction loss has been reduced by squaring the bore and stroke dimensions. The overhead valves, spherical combustion chambers, and greater compression ratio have improved the volumetric efficiency enough to increase power output even though piston displacement is less.

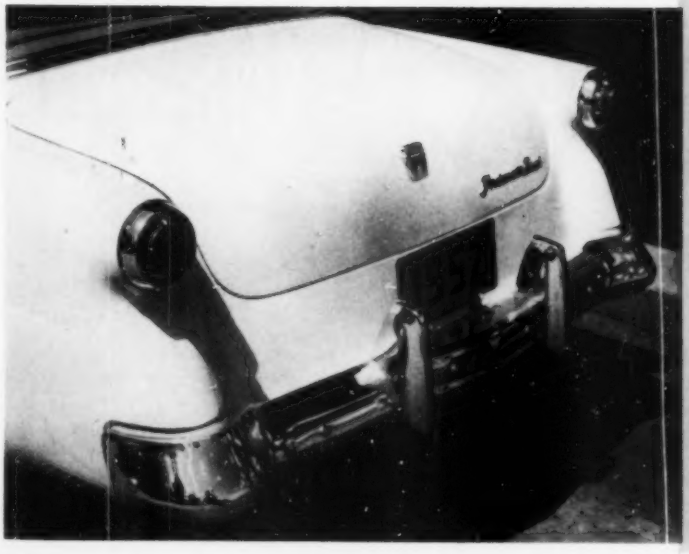
The compression ratio of the V-eight was increased by increasing the flow area over the valves and reducing the volume over the piston. The camshaft was also redesigned to increase the horsepower output.

An additional model, all-steel two-door station wagon —the Ranch Wagon—has been added to the Ford line, and the conventional station wagon has been switched from a 2-door to a 4-door design. This latter model, like the hard top and convertible is available only with a V-eight power plant, but all other body types can be obtained with either the six or eight cylinder engines.

Although the new exterior design maintains the established Ford theme, all models incorporate features that make the cars look longer, lower, and more luxurious. The extended headlight nacells in the fenders help give this impression.



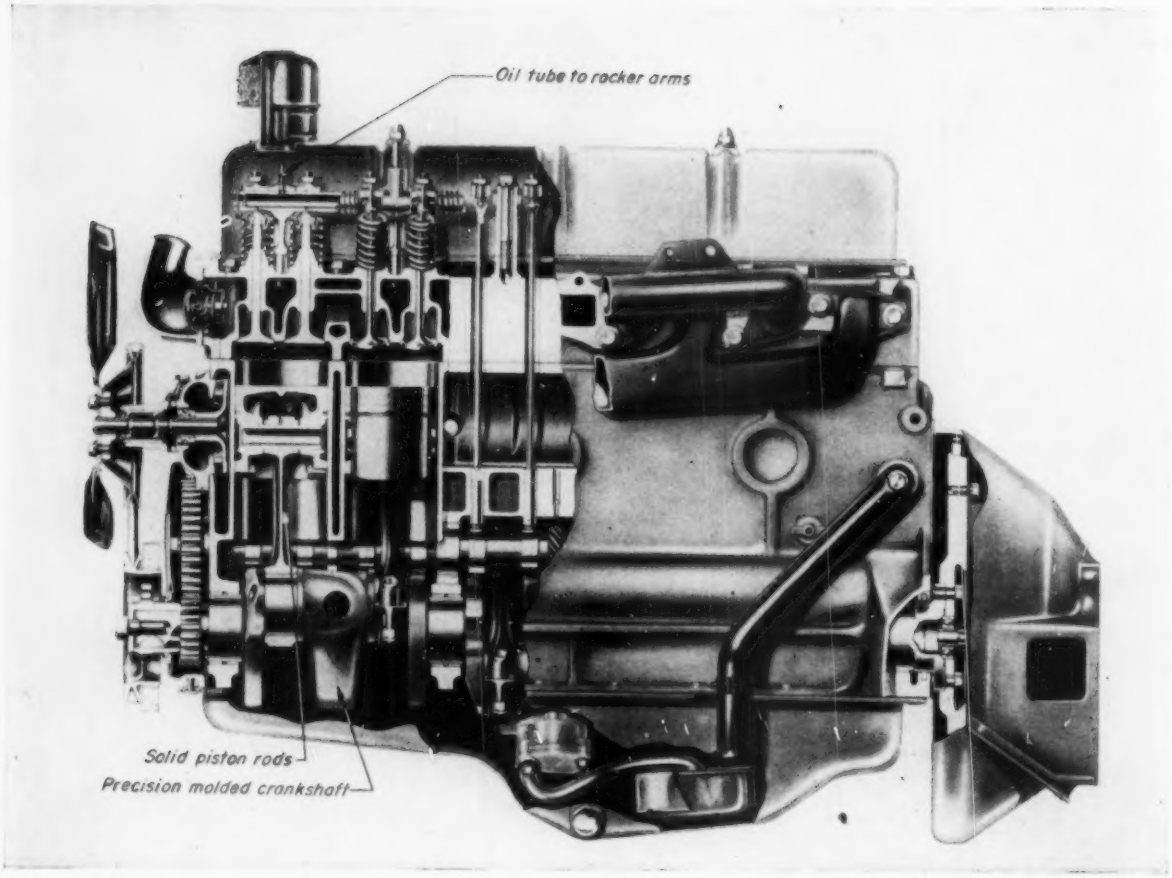
Six Cylinder Engine

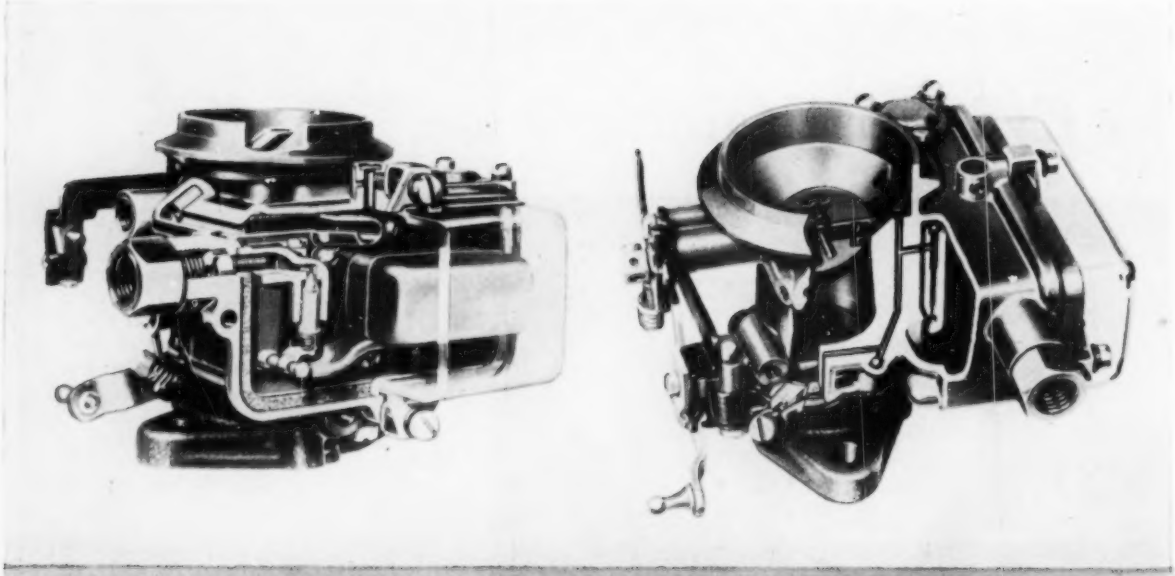


ON THE BLOCK of the new 6-cylinder engine a special boss was cast to receive the full flow oil filter. The ignition system has been moisture proofed and the carburetor has been shortened to fit under the lowered engine hood.

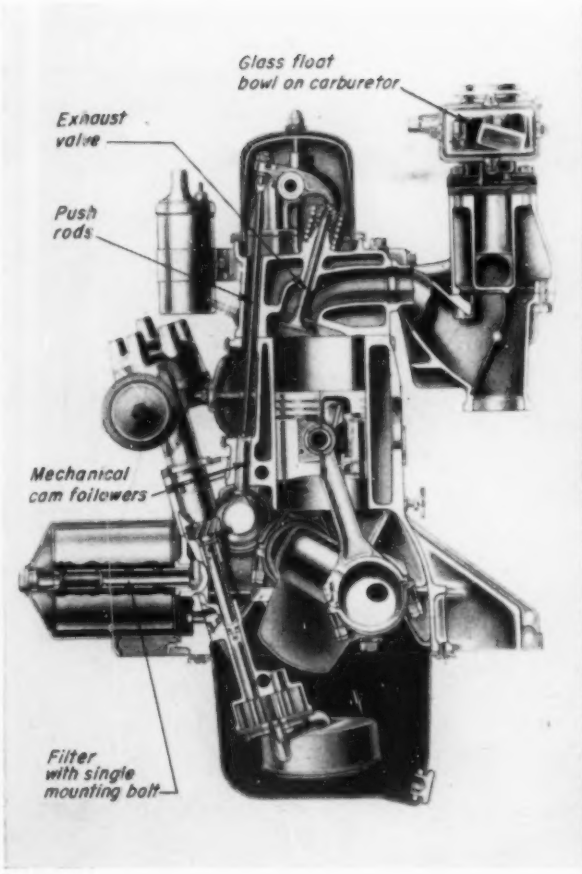
GRILLE is now a three spinner design in which the two outside spinners are combined with the turn indicator and parking lights. The curved one piece windshield is standard on all models. Window area of the Customline 4-door sedan has been increased. The wheel base of all models is 115 in., and overall length is 197.8 in. bumper guard to bumper guard.

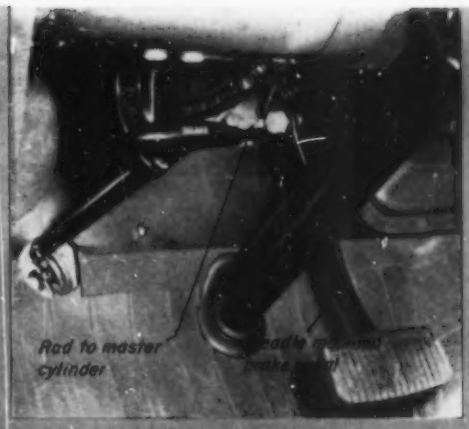
CIRCULAR TAIL LIGHTS incorporate the turn indicators with the red rear end markers. The license plate is held over the gas cap on a spring loaded bracket. The trunk lid springs partly open when the lock key is turned.





CARBURETOR OF FORD SIX. At left is a cutaway of the float circuit and the float chamber where the volume of immediately available fuel is maintained. The float bowl is made of clear glass and through it the level and condition of the fuel in the carburetor can be visually checked. One metering circuit is exposed in the cutaway view at right. The carburetor has one simple downdraft venturi tube and the choke valve and throttle valve are the conventional butterfly type. The choke valve is manually controlled.

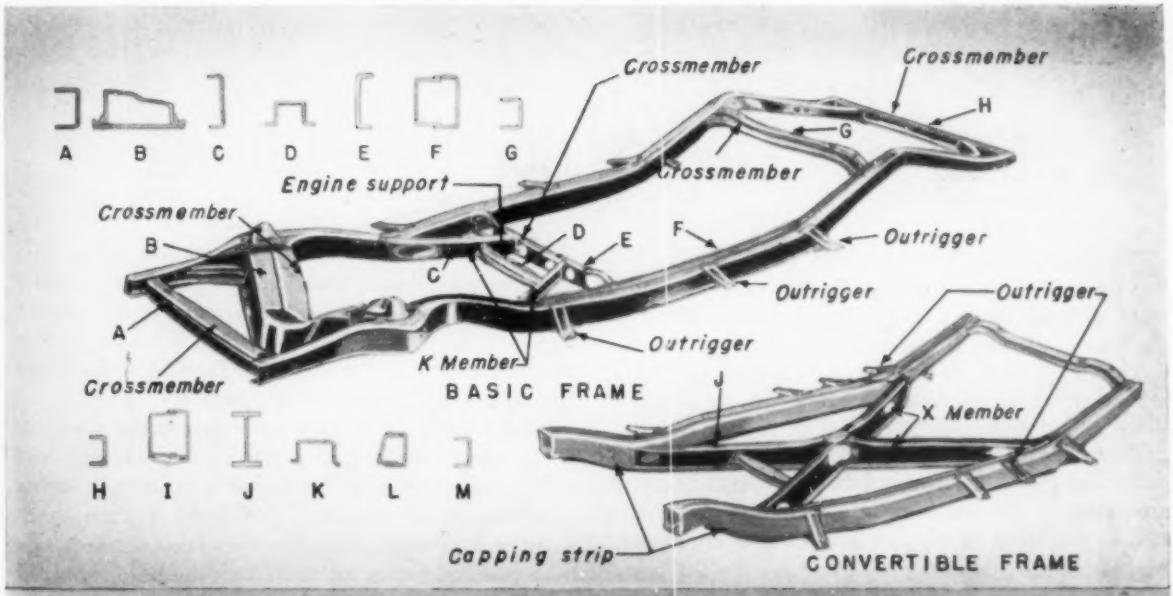




THE TREADLE MOUNTED brake pedal swings from a bracket mounted between the instrument panel and the fire wall. The master cylinder works directly with the motion of the brake pedal.

NO MACHINING but only grinding operations are required to finish the precision molded crankshaft. No pressure lubrication is directed to the wrist pins, pistons, or cylinder walls.

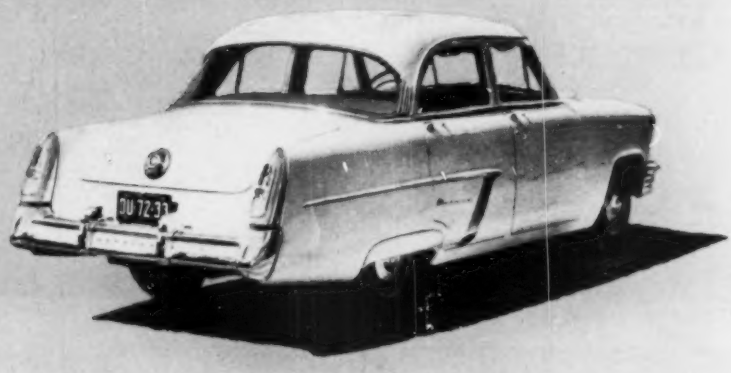
CYLINDER BORE is 3.56. Piston stroke is 3.6. The glass float bowl on the carburetor make visual check of fuel condition possible.



CROSS MEMBERS of the frames have been redesigned to increase torsional strength of chassis without increasing its weight. Lettered inserts show the cross sections of the frame members at the indicated points. The convertible frame is the basic frame with capping strips and X member added. Two extra outriggers on this frame provide more places for attaching the light convertible body.

AN ENLARGED HOOD ORNAMENT gives the appearance of an air scoop but it is non-functional. Bumper and grill are one piece. Salient dimensions of this 4-door custom sedan are 202 in. overall length, 73.5 in. width and 62.5 in. height at the curb.

HIGH TAIL LIGHTS are top to bottom: red driving lights, turn indicators, and back-up lights. The trunk lid springs partially open when the key is inserted into the lock and the lock is released.



Mercury Gets Major Face Lifting

The Mercury for '52 is low, long, and streamlined. A heavy one piece bumper and grill combination, extended front and rear fenders, and a low two-level hood profile help to produce this effect.

The two-level hood culminates in an enlarged hood ornament which resembles an air scoop but which is strictly decorative.

The new Mercury's tail and stop lights are housed in chromium plated die castings that appear to be upper extensions of the rear bumper, thus giving the rear as well as the front of the car, a distinctive appearance. And inside the passenger compartment, a revised instrument panel makes heater, defroster, air vent, and other control handles more accessible to the driver.

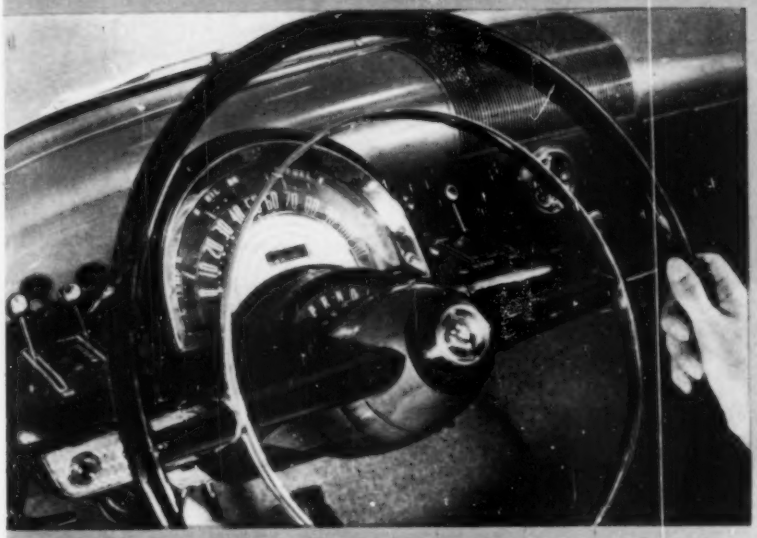
There are several mechanical refinements in body, chassis, and engine. Brake and clutch pedals are hinge mounted on a bracket under the instrument panel. The frame has been changed from an X to a rectangular type with box instead of channel sections for main structural elements. Doors of the four-door sedan open from the rear as in contrast with previous models where the rear doors hinged at their rear edges. Both front doors can be locked or unlocked from the outside.

Rubber bumpers are now mounted on the side rails of the frame near the front mounting of the rear springs to shorten effective spring length and increase spring rates during severe wheel movement. During quick starts or hard pulls, these bumpers keep the rear axle from twisting, reduce spring failures and have permitted a reduction in size of the torque tube tunnel in the passenger compartment.

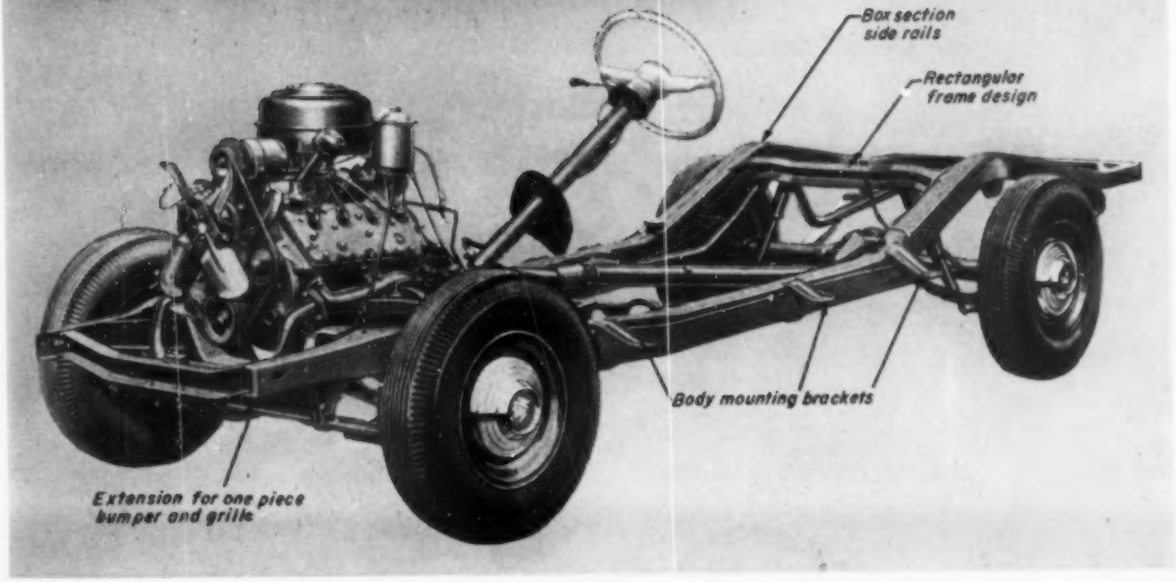
The new car has a wheel base of 118 in. and its revised high compression engine develops 125 hp., which is an increase of 13 hp. over previous models.

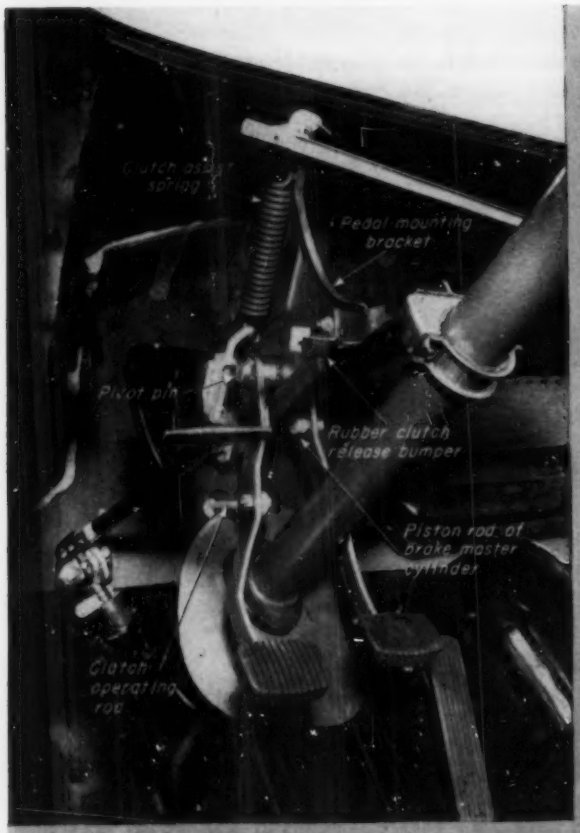
A SPRING LOADED mounting bracket holds the license plate over the gas tank filler cap. To expose the cap, the license plate can be tilted downward. Rubber bumpers separate the license from the body and protect the finish.

INSTRUMENT PANEL of the new Mercury resembles that of an airplane. Quadrant type levers control the heaters, the defroster, and the fresh air inlet vents. Mercury stylists consider this one of the most important appearance features in their new automobile.

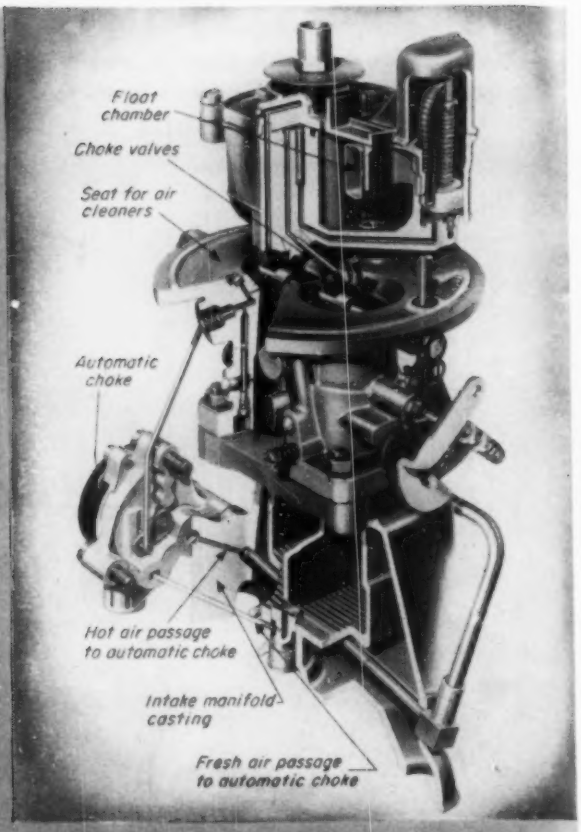


FRAME is now a rectangular type design instead of the previous X-type. Longitudinal members are double channels welded along top and bottom to form a box cross-section. More outriggers and side rail body mounts have been provided to make the body a more structural member of the chassis. The engine rides between the side rails and is positioned squarely on the centerline of the front wheels. A one piece bumper-grill unit bolts on to sections of the siderails that extend beyond the front crossmember of the frame.

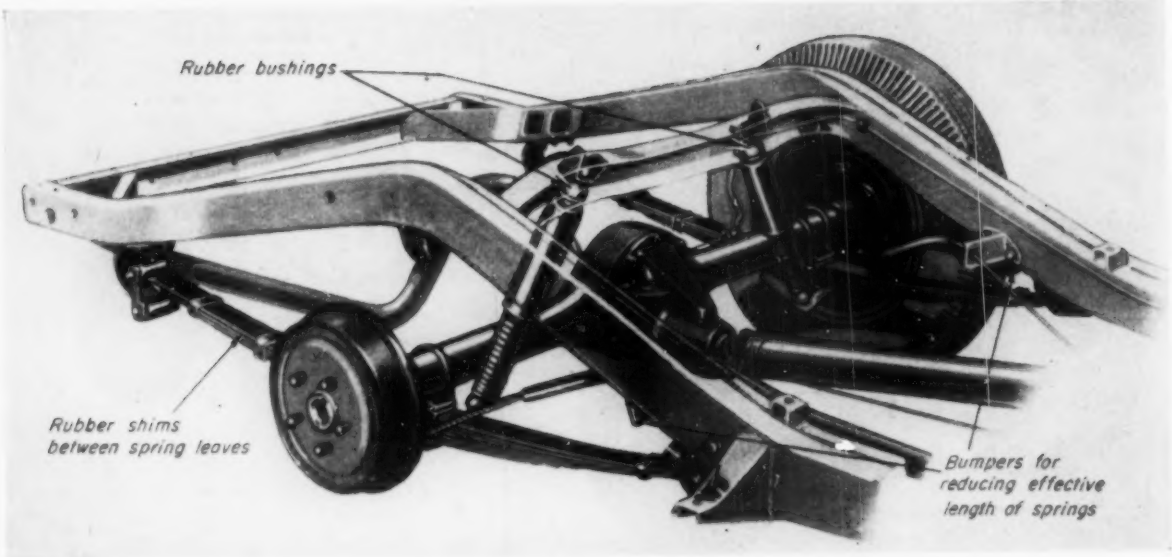


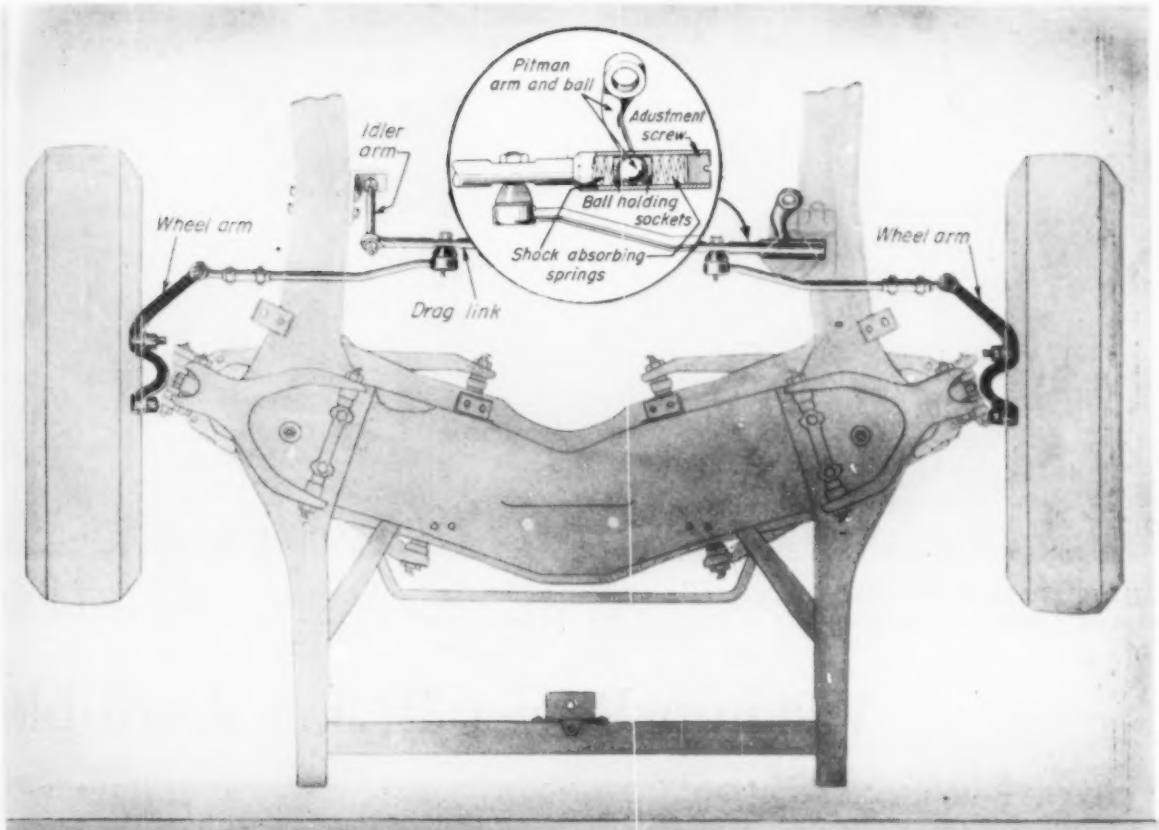


BOTH BRAKE and clutch pedals rotate on a common pivot bolt in the mounting bracket. A clutch booster spring assists the driver in compressing the clutch pedal, and a rubber bumper dampens pedal shock when clutch pedal pressure is suddenly released.

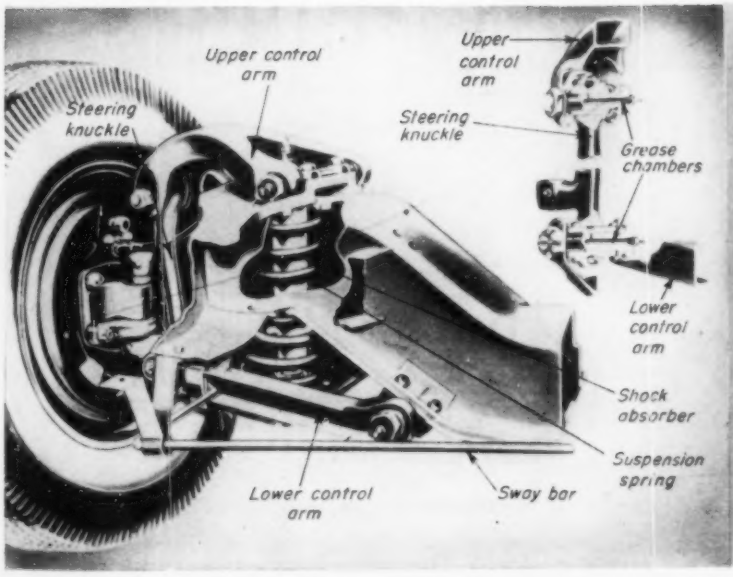


ENGINE INLET AIR CLEANER now fits around the carburetor float chamber. The automatic choke has been relocated further down on the engine to register a more accurate engine temperature. Air entering the automatic choke comes from the intake manifold.





STEERING LINKAGE. Road shock is isolated in the steering linkage and prevented from being transmitted to the steering wheel by a spring loaded ball socket joint between the pitman arm and the drag link. The overall steering ratio is 26 to 1 and the steering wheel will turn approximately 4½ times during a wheel position change from full travel in one direction to full travel in the opposite direction.



INSERTS separate the leaves of the semi-elleptic springs in the rear suspension system. Two auxiliary rubber bumpers reduce the effective length of the rear springs and increase their spring rates when spring deflection is excessive as may be encountered on bad roads or during quick starts.

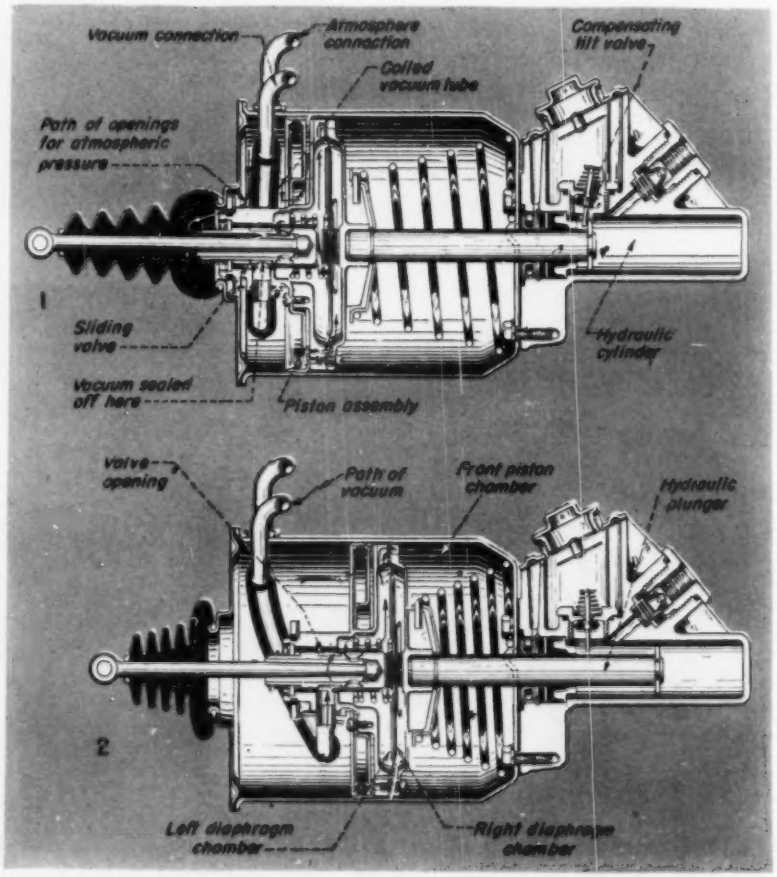
FRONT SUSPENSION SYSTEM. Telescoping hydraulic shock absorbers mounted inside the suspension springs have been made longer to give more even dampening over their range of travel. Special chambers in the front shock pins retain grease for lubrication of thread type bearing.

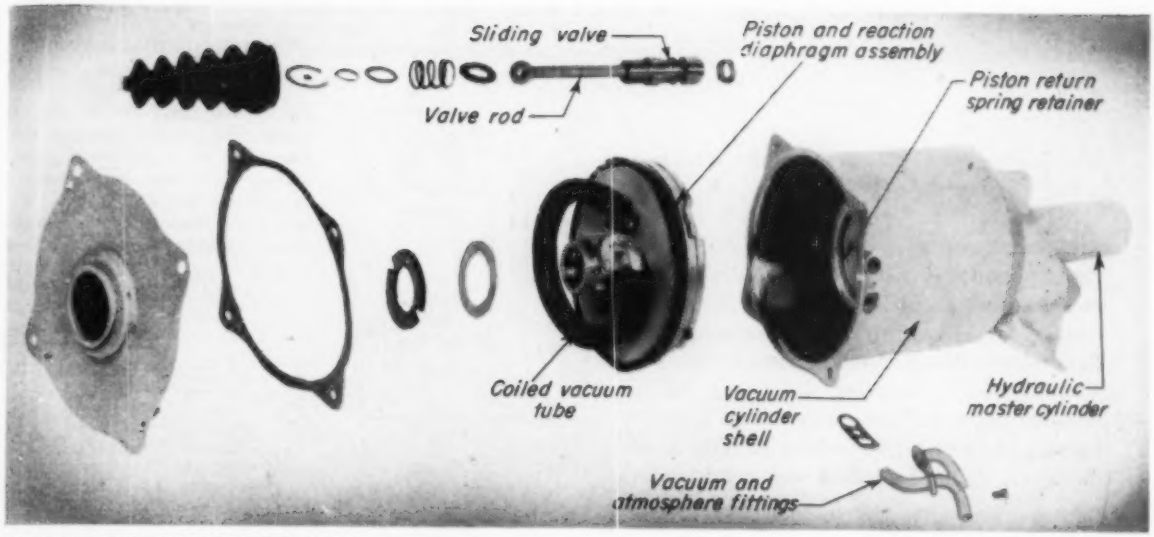
THE 1952 PACKARD PATRICIAN 400 is available only as a six passenger touring sedan. One of the major design features available on the new cars is a vacuum power hydraulic brake system that reduces brake pedal pressure.

Vacuum Power Brakes Available

One of the major mechanical features made available as optional equipment on the 1952 Packard cars is the "Easamatic" power brake system. It is similar to the conventional hydraulic brake system but includes a vacuum booster cylinder as an integral part of the master cylinder. Engine intake manifold vacuum is used to furnish power for the booster cylinder and a vacuum storage tank is provided for emergency use in case of engine failure. When the engine is not running, the brakes still operate as a conventional system. The brake lever is hinge mounted on the passenger compartment side of the fire wall and holds the treadle about four in. above the floor, as compared with the conventional vertical pedal which is nearly eight in. above the floor. In the interest of safety and smoothness, enough pedal resistance has been retained to give the operator the right feel of the brakes.

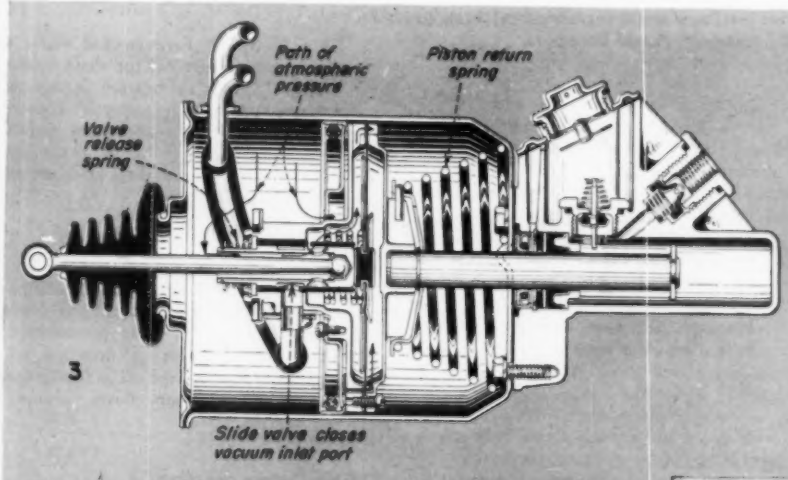
Other changes made in the new Packard include interior styling refinements and exterior paint schemes.





IMPORTANT PARTS AND ASSEMBLIES of vacuum power cylinder. On the sliding valve, notice the annular grooves that direct engine vacuum and atmospheric pressure to the piston reaction diaphragm and the cylinder.

on New, Restyled Packard Cars

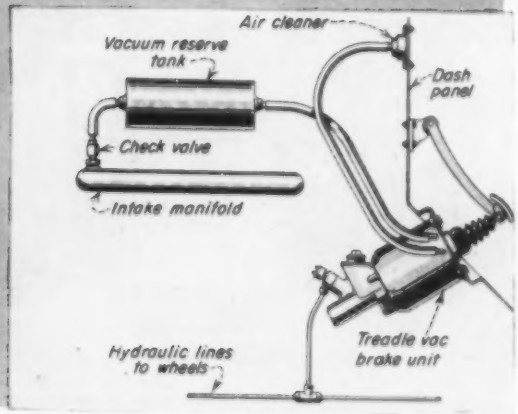


POWER for the Packard "Easamatic" brake is supplied by engine vacuum, working through a vacuum cylinder. The Easamatic unit is said to be the first integral vacuum power cylinder and hydraulic master cylinder combination in the industry. The unit is mounted to the engine side of the floor and acts directly with movement of the foot pedal.

1. When the brake pedal is released, engine vacuum is sealed from the cylinder at the port on the sliding valve. With air pressures balanced across the piston, the return spring holds the brake in the released position and the compensator valve in the hydraulic circuit is held open to permit hydraulic fluid to flow between the reservoir and the cylinder.

2. Brake pedal is depressed. The sliding valve opens passage from the vacuum tube to the left diaphragm chamber and front piston chamber. Differential pressure is brought across the piston and moves it forward, pushing the hydraulic plunger into the master cylinder and closing the compensator valve. Atmospheric pressure is ported into the right diaphragm chamber of the piston assembly to give proper feel of the brakes to the operator.

3. When the increased pedal pressure is stopped and the brake pedal is held in a static position, the sliding valve is forced back by the reaction spring and seals the imposed vacuum in the front vacuum chamber while the brakes are held in applied position. Release of foot pressure causes the valve release spring to move the sliding valve rearward, closing off vacuum to the left diaphragm and opening the front piston chamber to atmosphere.



Eleven Ways to Oil Lubricate

The method by which oil should be applied to a ball bearing depends largely on the surface speed of the balls. Where ball speeds are low, the quantity of oil present is of little importance, provided it is sufficient. Over-lubrication at low speeds is not likely to cause any serious temperature rise. However, as speeds increase, fluid friction due to churning must be avoided. This is done by reducing the amount of oil supplied and by having good drainage from the housing. At very high speeds, with light loads, the oil supply can be limited to a very fine mist.

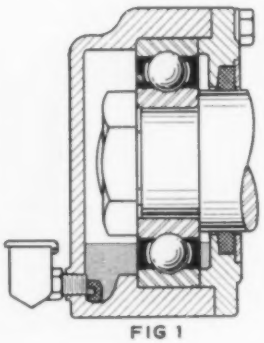


FIG 1

Fig. 1—*Oil Level System.* For moderate speeds, the bearing housing should be filled with oil to the lowest point of the bearing inner race. An oil cup is located to maintain this supply level. Wick acts as a filter when fresh oil is added. This system requires periodic attention.

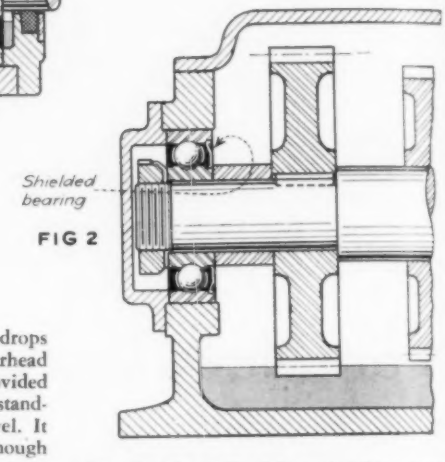


FIG 2

Fig. 2—*Splash Feed* is used where rotating parts require oil for their own lubrication. Splash lubrication is not recommended for high speeds because of possible churning. Bearings should be protected from chips or other foreign material by using a shaft mounted slinger or shielded bearings.

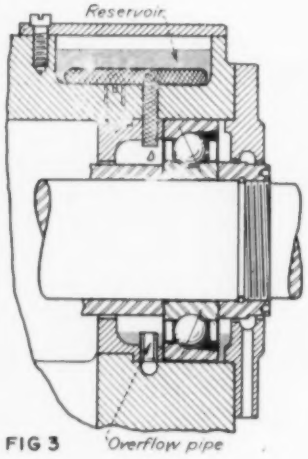


FIG 3

Fig. 3—*Drop Feed.* Oil may be fed in drops using either sight-feed oilers or an overhead reservoir and wick. Drains must be provided to remove excess oil. A short overflow standpipe, serves to maintain a proper oil level. It also retains a small amount of oil even though the reservoir should be empty.

Fig. 4—*Spray Feed.* With higher speeds, definite control of oil fed to bearings is important. This problem is more difficult for vertical bearings because of oil leakage. One method uses a tapered slinger to spray oil into the bearings. Oil flow is altered by the hole diam., the taper and oil viscosity.

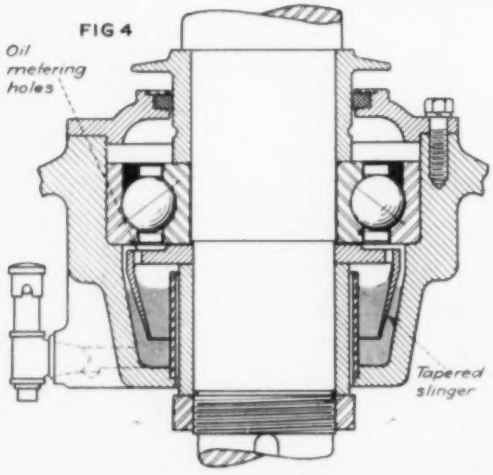


FIG 4

Fig. 5—*Circulating Feed.* Most circulating systems are somewhat complicated and expensive but this is justified by their permanence and reliability. Oil reservoir is attached to the shaft and when rotated, the oil is forced upward where it strikes a scoop, flows through and onto the bearing.

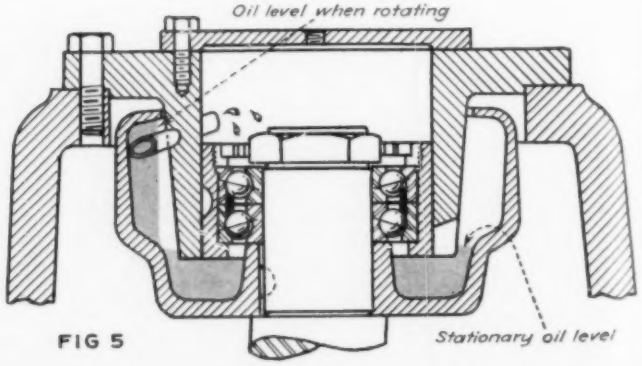


FIG 5

Ball Bearings

D. L. WILLIAMS
New Departure Div., General Motors Corporation

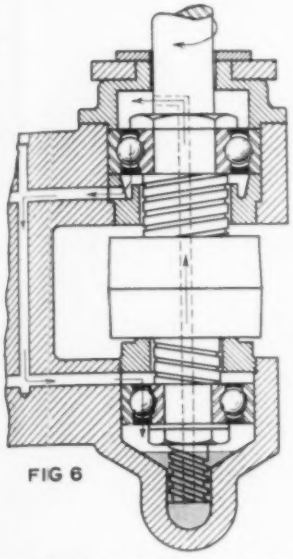


FIG 6

Fig. 6—*Most circulating systems* are used for vertical shaft applications and usually where ball speeds are comparatively high. One system consists of an external screw which pumps the oil upward through the hollow spindle to a point above the top bearings.

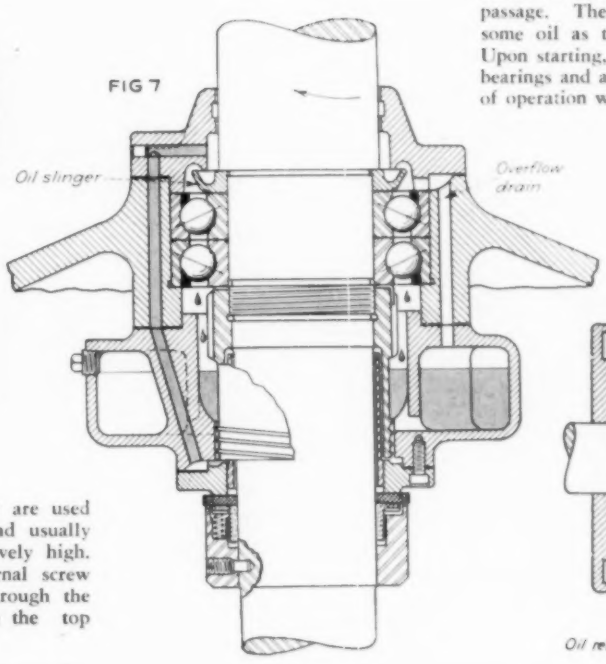


FIG 7

Fig. 7—*Another screw pump application* forces the oil upward through an external passage. The cup-shaped slinger traps some oil as the spindle comes to rest. Upon starting, this oil is thrown into the bearings and avoids a short initial period of operation with dry bearings.

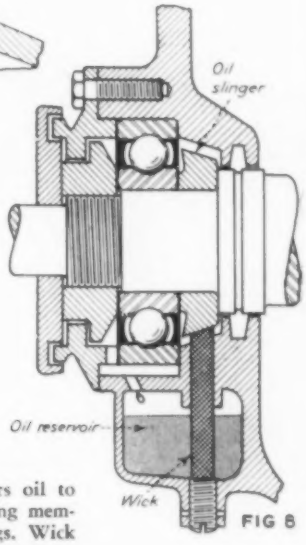


FIG 8

Fig. 8—*Wick Feed* filters and transfers oil to a smoothly finished and tapered rotating member which sprays a mist into bearings. Wick should be in light contact with the slinger or else the wick may become glazed or charred. A light spring is often used for proper wick pressure.

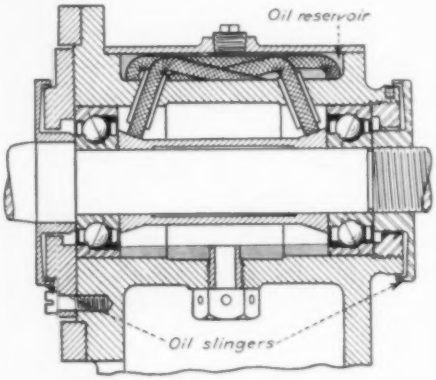


FIG 9

Fig. 9—*Wick feeds* are used in applications of extremely high speeds with light loads and where a very small quantity of oil is required in the form of a fine mist. Slingers clamped on the outside tend to draw the mist through the bearings.

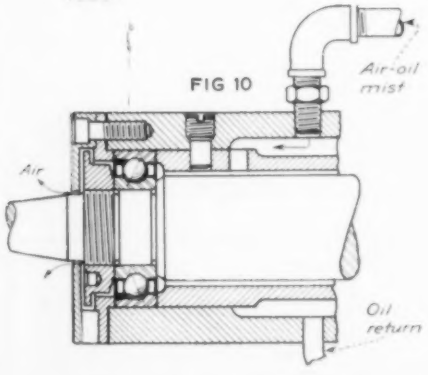


FIG 10

Fig. 10—*Air-Oil Mist.* Where the speeds are quite high and the bearing loads relatively light, the air-oil mist system has proven successful in many applications. Very little oil is consumed and the air flow serves to cool bearings.

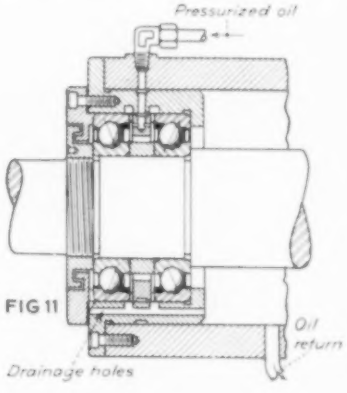


FIG 11

Fig. 11—*Pressure Jet.* For high speeds and heavy loads, the oil must often function as a coolant. This method utilizes a solid jet of cool oil which is directed into the bearings. Here adequate drainage is especially important. The oil jets may be formed integrally with the outer preload spacer.

Table I—Properties of Typical Hard Rubber Compounds

Principal Characteristics or Uses	Tensile Strength Psi	Color	Elong. %	Sp. Gr.	Rockwell Pen.-Rec.	Shore Durometer D Hardness	Izod Impact Strength ft. lb./in. notch	Flexural Strength MFS/Psi	Heat Distortion Temp. Deg. F.	Dielectric Strength 60 Cycles, v/mil.
MOLDED ARTICLES										
General Purposes	8300	Black	4.00	1.21	108-76	81-87	0.48	12500	142	435
General Purposes	7900	Black	4.00	1.21	107-91	81-87	0.45	11340	145	496
General Purposes	4500	Black	3.40	1.28	129-79	78-84	0.45	7125	134	344
General Purposes	2000	Black	2.00	1.54	103-27	76-82	0.27	2818	Low	377
High Heat Resistance	6750	Red-Brown	2.60	1.65	83-60	85-92	0.35	8675	283	393
High Arc Resistance, Heat and Wear Resistance	4000	Red-Brown	1.00	1.95	65-41	87-95	0.32	8400	300	600
Arc, Heat, Wear Resistance, High Dielectric Quality	5800	Red-Brown	2.60	1.71	82-55	86-92	0.38	9060	246	371
Heat Resistance, Low Moisture Absorption	5400	Black	1.80	1.80	82-54	84-92	0.34	10000	295	420
SHEETS										
General Purposes	9300	Black	5.00	1.20	112-79	80-86	0.48	16600	159	487
General Purposes	8300	Black	4.10	1.21	108-76	80-86	0.48	12625	142	435
General Purposes	6750	Black	4.20	1.21	126-78	80-86	0.44	12600	134	474
High Elongation (Semi-Hard)	2550	Black	33.00	1.17		50-60	0.51		Low	437
High Heat Resistance	7400	Black	1.20	1.43	86-60	86-92	0.53	9640	221	613
Strength, Flow Resistance, High Dielectric Quality	7450	Yellow-Brown	5.30	1.27	112-80	80-86	0.50	14950	150	415
RODS AND TUBES										
General Purposes	9700	Black	5.00	1.21	107-70	80-86	0.48	11375	163	524
General Purposes	7500	Black	3.00	1.21	116-82	80-86	0.47	11130	146	462
High Elongation	3600	Black	16.00	1.15		65-75	0.48		Low	512
Strength, Flow Resistance, High Dielectric Quality	6500	Yellow-Brown	3.80	1.27	112-80	80-86	0.52	9060	217	374

Hard Rubber in general has a Coefficient of Linear Expansion of 0.00004/deg. F.
Note: All values shown are representative average test results.

What You Should Know About *Hard*

For good strength properties, high chemical resistance, and good dimensional stability, hard rubber is hard to beat. What's more, it can be formed by molding, extrusion, blowing, pressing or stamping.

HARD RUBBER is a thermosetting material that combines many of the chemical, mechanical and electrical properties of plastics. Its outstanding characteristics can be summarized as follows:

1. It has good chemical resistance, being immune to attack by most acid and alkali solutions and fumes.
2. It has exceptional electrical insulating properties at both high and low frequencies.
3. Its resistance to impact and shock is high. Exceptionally tough grades can be made by special compounding techniques.
4. Its moisture absorption is low.
5. It is odorless, tasteless, and sanitary, since it can be sterilized with no adverse effects.
6. It has good thermal insulating properties.
7. It can be given a high surface polish.
8. It is non-flammable and not readily ignited.
9. It is readily molded to desired shape.
10. Its machinability is superior to many plastics.

Hard rubber is made by adding 25 percent or more sulphur to natural or synthetic rubber and subsequently vulcanizing the mixture. Ordinarily, natural rubber stock is used. Generally

Dielectric Strength 60 Cycles, v/mil.	Power Factor 1 Megacycle %	Dielectric Constant 1 Megacycle	Surface Resistance Megohms at 74° F 86% R. H.	Water Absorp. 48 hrs. at Room Temp.
435	0.8	3.00	4.8×10^5	.08
496	0.7	2.95	over 10^8	.06
344	1.2	3.80	over 10^8	.14
377	2.8	4.95	5.08×10^5	.30
393	1.2	4.10	5.32×10^8	.06
600	2.5	4.80	Arc Resistance 248	.06
371	1.2	4.60	4.46×10^4	.10
420	1.8	4.10	8.02×10^4	.04
487	0.5	2.95	2.23×10^7	.06
435	0.8	3.00	4.81×10^5	.08
474	0.6	3.05	1.24×10^4	.08
437	1.3	3.00	2.66×10^4	.22
613	0.6	3.25	over 10^8	.15
415	0.6	3.70	7.98×10^4	.08
524	0.5	2.90	over 10^8	.06
462	0.9	2.80	over 10^8	.10
512	1.4	3.15	over 10^8	.12
374	0.9	3.60	6.73×10^4	.07

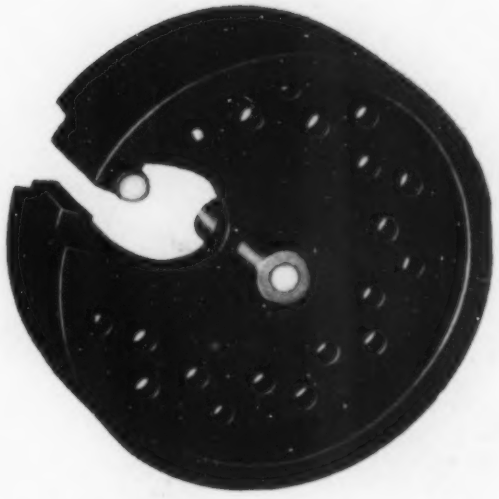


Fig. 1—Pistons for positive displacement liquid meters are molded of hard rubber. The low specific gravity of hard rubber and the close machined tolerances attainable result in high accuracy.

Table II — Impact Resistant Resin-Rubber Blends

	Flexible Grade	Rigid Grade
Color	Black Standard; Others Available	
Specific Gravity	1.05-1.40	1.05-1.40
Tensile Str., psi	1000-2500	2000-3500
Elongation, %	70-200	2-30
Flexural Str., psi	3300	4800-7000
Izod Impact Str., ft. lb./in. notch	3.0-10.0	1.0-4.0
Durometer "D" Hardness	38-60	68-72
Rockwell Hardness: Penetration	—	190-200
Recovery	—	76-200
Heat Distortion, F.		125-150
Dielectric Str., 60 cyc., V/mil	Up to 500	400-500
Dielectric Constant	3.0*	2.70-3.50
Power Factor, %	0.47-0.65	0.70-2.00
Surface Resistivity, ohms	Up to 5.0×10^{10}	2.0×10^{10}*
Water Absorption	Very low	Very low

*Approximately.

Rubber

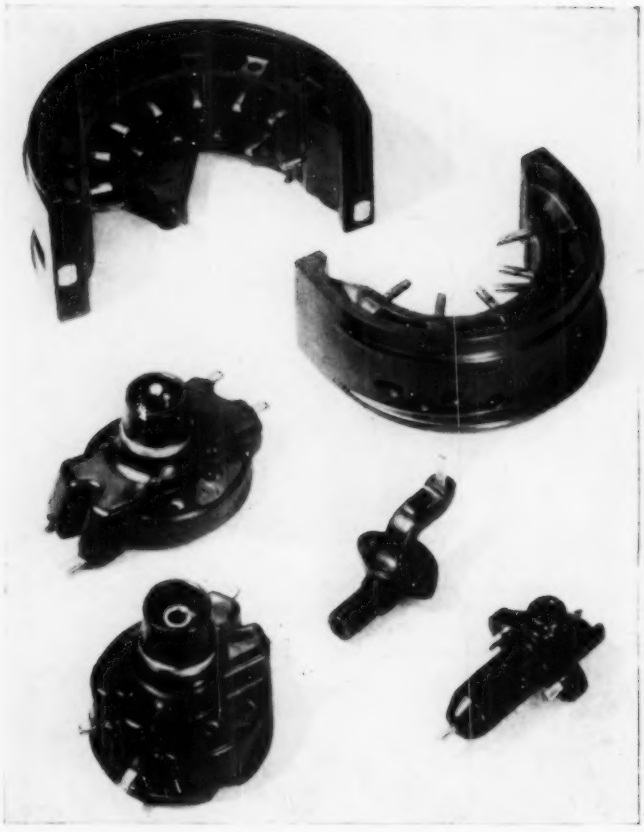
A. J. LORENZ
Product Development Engineer
American Hard Rubber Company

the properties obtained through the use of synthetic rubbers closely approach those of natural rubber. Compounds with superior heat, oil and solvent resistance can be made from the acrylonitrile rubbers.

The advantages of the crude hard rubber over synthetics in general are lower water absorption and swelling and better impact strength. It is possible that improved synthetics may gradually replace natural rubber in many hard rubber compounds.

Hard rubber compounds can be varied to suit many applications and to meet various mechanical, processing and fabrication requirements. The properties of the available compounds are listed in Table I. One method by which variation in properties is attained is by the incorporation of various filler materials such as mica, graphite and other forms of carbon, and wood flour. Many stocks contain hard rubber dust as a filler, mainly to cut down the exothermic reaction during curing. Many mineral fillers can be added to lower cost, increase stiffness and heat resistance, improve wear resistance, decrease distortion or to give good electrical properties. These fillers do not improve strength qualities, usually decrease machinability.

Other methods of varying properties include changing curing time, temperature, or pressure; or by adding



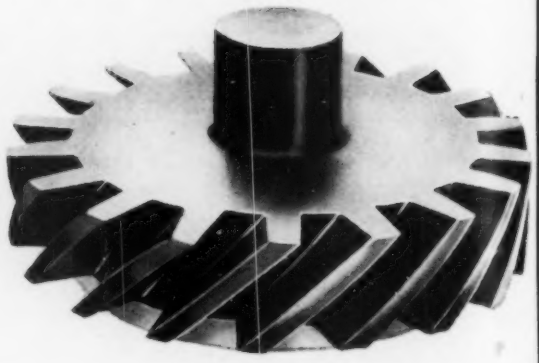


Fig. 3—Hollow products like the above liquid meter impeller are made by the blowing process. The lighter weight provided by the hollow center results in higher accuracy of meter registration.

Fig. 2—Many electrical parts are molded of hard rubber. Both compression molding and transfer molding techniques are used, the latter being more desirable when complicated inserts are used. Hard rubber has good electrical properties at both high and low frequencies and has excellent resistance to moisture absorption.

softening materials or pigments.

Special grades of hard rubber include conductive rubber, hard rubber for electronics, porous hard rubber and high impact resistant resin-rubber blends. Conductive hard rubber is used where safety precautions require grounding of static electricity; this material is available in rods, sheets and tubes with varying conductive qualities. For radio, television, radar and other electronic applications, grades are obtainable with exceptional dielectric strength, low dissipation factor, and low dielectric constant.

The compatibility of rubber for some thermoplastic resins is used to advantage in the production of high impact resin-rubber blends. These compounds are made of styrene copolymer resins with natural or synthetic rubber added to give increased flexibility and high impact strength. Uses of these materials, Table III, include tool handles, protective helmets, trays, buckets, Textile bobbins and acid vent ducts.

Methods of Forming

Hard rubber can be formed by molding, extrusion, pressing, blowing, or stamping. Compression molding is perhaps the most widely used molding process for industrial parts. High production is attainable by the use of multiple cavity molds. Size of parts is limited only by press capacity, and inserts can readily be incorporated in the molded product. Since flow lines are not experienced as frequently as with some thermoplastics, complicated shapes can be handled.

The cost per piece of hard rubber molded products depends upon the quantity of parts required, the size and complexity of the part, tolerances desired and the surface finish. Tolerances should not be specified closer than necessary for proper functioning of the parts. Normal tolerances of straight molded units are ± 0.006 inches per lineal inch. Where dimensions are measured across parting lines an additional 0.020 in. tolerance is required to allow for variations in flash thickness.

An example of a precision molding is the piston shown in Fig. 1, which is designed for high accuracy in measuring the amount of water passing through a meter. Operating clearances between the piston surfaces and the walls of the measuring chamber are only a few thousandths of an inch. Low specific gravity and good wear resistance contribute to accurate registration and long life. The meters operate for many years with only a slight drop in accuracy.

Transfer Molding—This molding process is especially adaptable for the production of parts containing complicated inserts. In compression molding the insert is subjected to a high and non-uniform pressure as it resists the flow of the comparatively cold rubber compact. In transfer molding the rubber is heated separately in a chamber and the semi-liquid rubber is forced into the mold cavity. The rubber flows easily around the insert. Many electronic parts, Fig. 2, are molded by this process.

Blowing—The blowing process is used in the production of hollow parts. A gas or vapor producing medium, such as water, is placed in the mold and surrounded by the necessary amount of rubber. The rubber is hand fitted into the mold cavity and the pieces held together with cement. During the cure the evolved gas forces the softened rubber against the walls of the mold, producing a hollow part, Fig. 3, with fairly good section uniformity. The necessary hand fitting and the long cures make this process

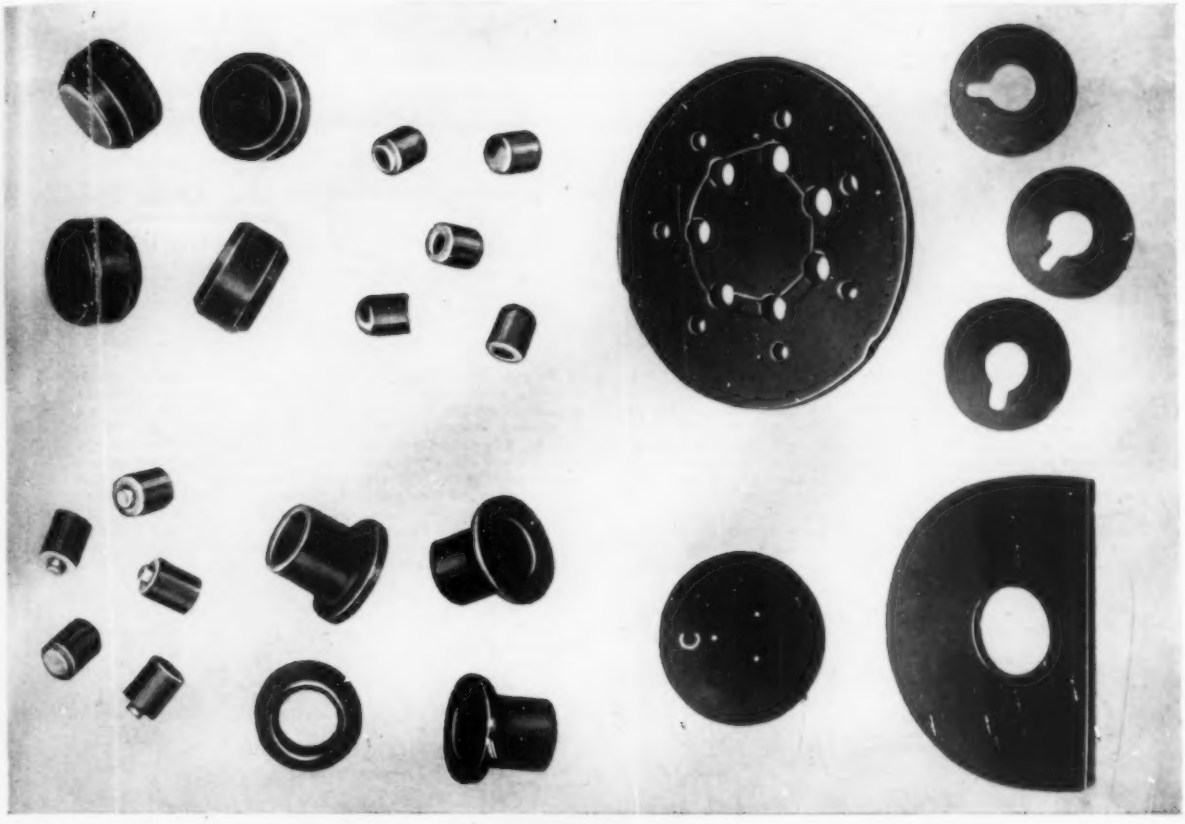


Fig. 4—Extruded hard rubber parts. At left are shown some of the small bearings and bushing fabricated from extruded stock. The electrical connectors, right, were also cut from single and multi-hole extruded tubing.

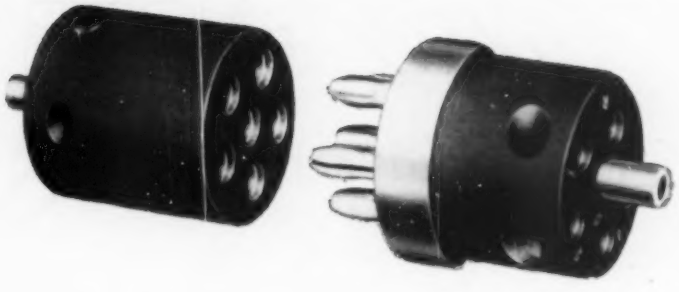


Fig. 5—These electrical connection parts were fabricated from multi-holed tubing; the side holes were drilled.

much slower and more costly than the other more widely used processes mentioned above.

Sheet Pressing—For parts of simple shape that require good accuracy and a smooth bright finish a special pressing process is used. The unvulcanized rubber is die pressed while warm between sheets of tin-foil. After vulcanizing, the foil is removed, leaving a smooth accurate surface.

Extrusion—As with other engineering materials, many hard rubber parts formed from tubing or bar stock can be made economically by extrusion. Special extruded products include multi-holed tubing with as many as six holes, Fig. 4, and tubing extruded directly on metal rods.

Hard rubber sleeve and roller bearings and bushings fabricated from rod and tube stock have good wearing qualities and can effectively replace metal in many applications—frequently at lower cost. Rods can be centerless ground to close tolerances and a fine finish to provide better frictional characteristics.

Other products fabricated from extruded hard rubber stock include fountain pen feed rods, small cams and rollers, and electrical insulating parts.

Other Forms and Applications

Many parts can be made economically by punching from flat sheets of hard rubber. Various grades and smooth or decorative finishes are attainable. Perforated and slotted ribbed hard rubber sheet can be used effectively to replace copper or other metal screening in liquid meters, sediment traps and other industrial products requiring protection against sediment. Coverings and linings are used extensively for protecting pipes, pumps, valves, and tanks against corrosion in the chemical industry.

Where quantities are small, mold cost often can be avoided by hand-building hard rubber articles. Calendered rubber sheet is cut to shape and then wrapped and formed around metal cores or mandrels prior to vulcanization. This method is also ad-

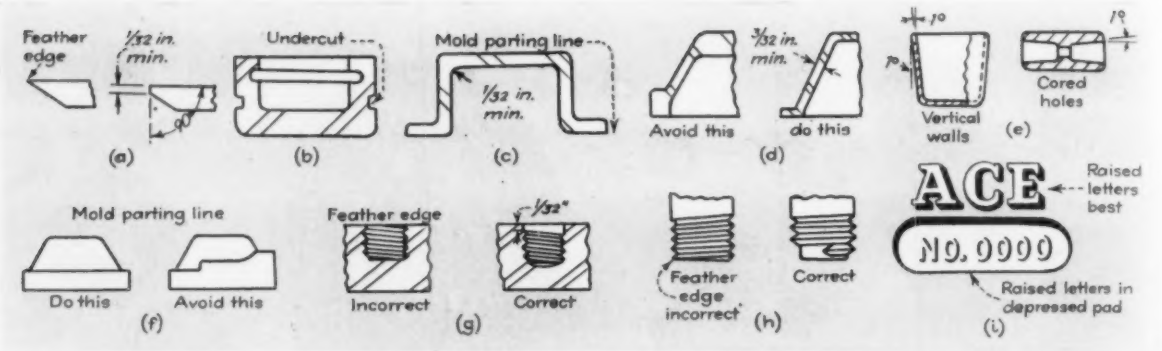


Fig. 6—Design Considerations for Molded Hard Rubber Parts. (a) Feather edges are easily broken and should be avoided. Allow 1/32 inch minimum edge thickness. (b) Undercuts are cheaper to machine than to mold. Molding requires split bars and molding speeds are slow. (c) Edge and corner radii should be 1/32 in. minimum to provide strength, better appearance and better molding and to prevent breakage. Radii at parting line should be avoided. (d) To reduce curing time, maintain as light and uniform a section as practical, but not less than 3/32 inch. For uniform cure, sections of varying thickness should be avoided. (e) At least one degree draft or taper should be allowed on all surfaces perpendicular to the parting line to facilitate removal of the piece from the mold. (f) For economy in molding and in finishing, parts should be designed so that the parting line is in a horizontal straight line. (g) To facilitate assembly of parts and to prevent chipping a recess should be provided for female threads. The diameter of the recess should equal the major thread diameter and the depth should be 1/32 inch. (h) Male threads should start about 1/32 inch back from the end. Feather edges on both male and female threads should be avoided. (i) For trade names, part numbers, etc., raised letters will result in lower mold cost than depressed letters. Raised letters in a depressed pad will keep the letters from projecting above the surface. Smooth edges on the letters or numbers will facilitate removal of the part.

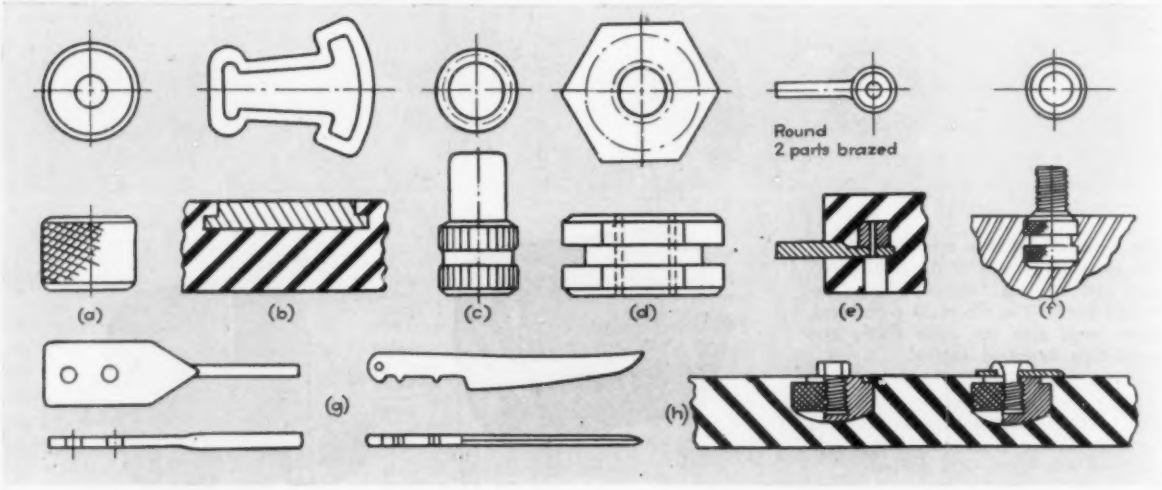


Fig. 7—Design of Metal Inserts. (a) Coarse diamond knurl—good for cylindrical inserts. Only the portion to be embedded in the rubber should be knurled. (b) Flat inserts require undercutting. (c) A plain straight knurl will keep the insert from twisting but an undercut is necessary to prevent pulling out. (d) Similarly, hex or square stock should be undercut. (e) Projecting end of insert should be a standard shape to facilitate pre-positioning in the mold. Long slender or unsupported inserts may distort or move during molding. (f) To prevent rubber from flowing into the threads a shoulder should be added as illustrated, to form a seal during the molding operation. (g) Puched tangs or holes give a firm grip to inserts of flat or extruded stock. (h) To attach strips, the insert should be molded as at left and the strip assembled by spinning over the head of the insert, right. Connecting two or more inserts is not desirable because of the variation in coefficients of expansion of hard rubber and metal.

vantageous for large regularly shaped parts such as tanks, battery boxes, special containers and pipe fittings.

Design Factors

The basic principles that must be considered when designing molded hard rubber products have been established by years of experience. The sketches in Fig. 6 illustrate the most important details.

In molding metal inserts into the hard rubber products the insert should be designed for anchorage by one of more of the methods illustrated in Fig. 7. These techniques plus the added grip provided by the shrinkage of the rubber will give satisfactory results. Shrinkage will vary somewhat with different compounds ranging from 0.01 to 0.04 inches per inch.

The insert designs shown in Fig. 7 apply also where assembly is done after molding. The drilled or molded hole should be 0.003 to 0.006 inches smaller than the insert.

Assembly after molding is often desirable to permit the use of the same molded part for several different sizes of inserts without resorting to additional mold expenditure.

Materials for inserts include brass, steel, monel, aluminum and porcelain. The copper content of brass inserts should be kept below 70 percent to prevent corrosion of the metal by the sulphur in the rubber. Tin plating the insert is effective in preventing corrosion.

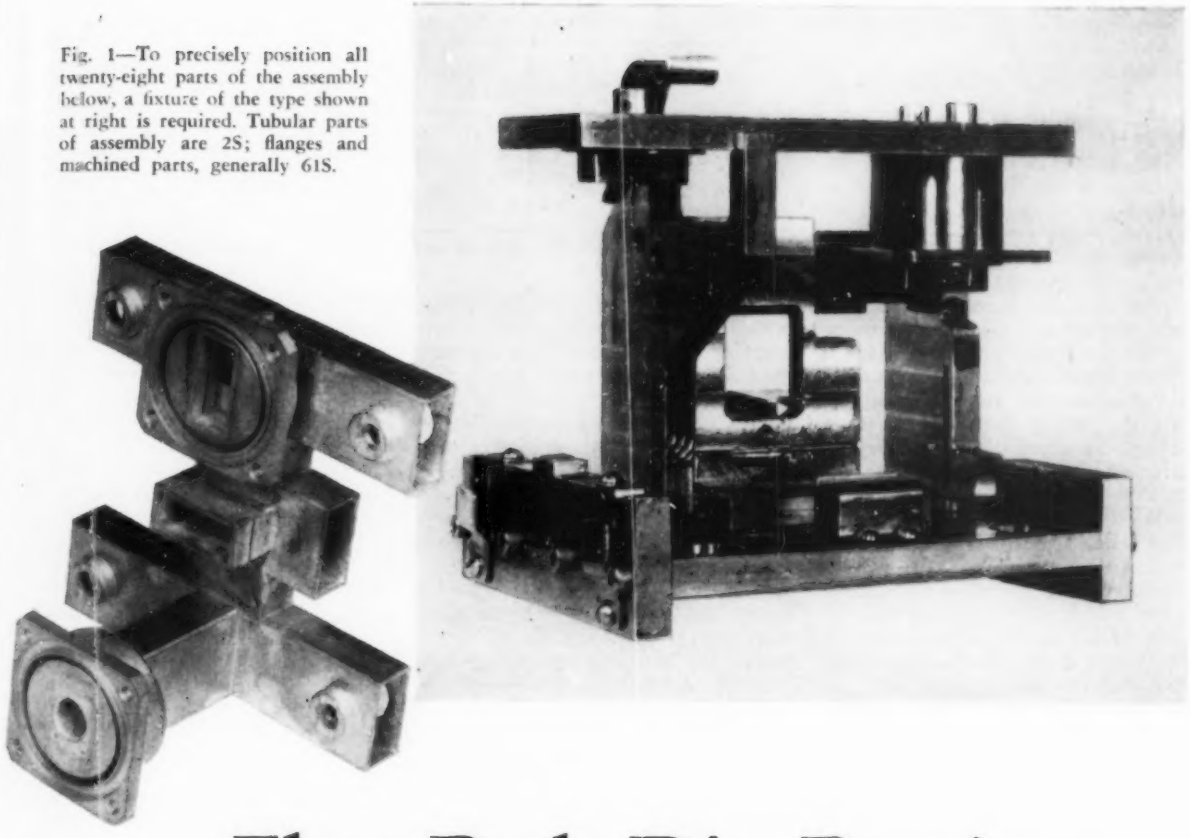


Fig. 1—To precisely position all twenty-eight parts of the assembly below, a fixture of the type shown at right is required. Tubular parts of assembly are 2S; flanges and machined parts, generally 61S.

Flux Bath Dip Brazing Of Aluminum Alloys

D. WALLACE
Sperry Gyroscope Company

SUCCESSFUL BRAZING depends to a large extent on the difference between the melting temperatures of the filler and parent metal, the extent to which the parts can be heated uniformly and the precision of the temperature controls. Matching of the parent and filler materials is also an important factor. When brazing aluminum, an aluminum-base filler alloy is necessary for optimum corrosion resistance because the galvanic couple between the filler alloy and the base metal is negligible. In addition, the presence of an aluminum filler metal in the joint permits the use of corrosion-protective anodizing treatments that are not usually feasible unless the filler is an aluminum alloy.

The main difficulty with aluminum brazing lies in the small difference between the melting temperatures of the filler and base metal. This difficulty is minimized, the higher the solidus temperature of the base is above the liquidus temperature of the filler alloy; and conversely, this difficulty increases as the liquidus temperature of the filler alloy approaches the solidus temperature of the base metal.

Once the differential between melting temperatures is established, the other procedural prerequisites are considered. If distortion, sagging or melting of the base metal is to be avoided, mating parts must be heated rapidly and uniformly and all temperatures precisely controlled. In addition, the time during which molten filler metal is in contact with the solid base metal should be limited. Too long a contact period, as well as excessive filler alloy, often results in solution of the base metal or localized melting. Close control of these variables can be obtained by using a molten salt bath, which in the case of aluminum brazing, serves also as the fluxing medium.

Another important consideration in brazing aluminum is joint corrosion resulting from flux entrapment. This is difficult to avoid when aluminum brazing with paste mixtures of alcohol or water and flux. Dry flux has some advantages over the wet paste, but flux entrapment may still persist because the salts contain water. The molten flux bath is a truly dehydrated flux for the reason that it is prepared by melting the salts and then immersing a sheet of 2S aluminum. The latter serves to remove the moisture in the flux by combining with it and evolving hydrogen, which burns at the surface of the molten flux. Joints prepared by immersion in such flux and properly

washed have shown no evidence of corrosion after 250 hr in a high-humidity chamber maintained at 95 Fahrenheit.

Details of Process

The procedure for preparing aluminum parts for brazing consists of cleaning in an alkali bath or vapor degreaser, bright dipping in a bath consisting of three parts concentrated nitric acid and one part concentrated hydrofluoric acid at room temperature, and rinsing in cold and hot water.

The dried parts are assembled in a fixture, the brazing alloy preplaced at the joint and the assembly heated at 950 to 1,000 F. for about 10 to 25 min in an electrically heated air furnace. After a quick transfer to the brazing furnace, assembly is immersed in the bath for 15 to 30 sec at 1,100 F. The brazed assembly is then permitted to cool in air to below 212 F and immediately washed in clean hot water at about 200 F. The final step after removal from the fixture is finishing by acid bright dipping and/or anodizing.

Alcoa's dip brazing fluxes #53 and #34 consist of fluorides and chlorides that attack heating elements, alloy pots and furnace linings. Salt bath furnaces with electrodes partially immersed become corroded at the air-flux line. The development of the Upton salt bath furnace, with electrodes completely covered by flux, has solved this problem to a large extent.

To braze precision aluminum assemblies consisting of thin-wall tubing, flanges and bends, properly designed fixtures should be used. A 28-part assembly and typical fixture in which it is brazed are shown in Fig 1. Because they must be submerged in the bath, fixtures are fabricated from Monel, K-Monel, austenitic stainless steels or Inconel. These alloys are all subject to some surface attack but the life of the fixture is not greatly affected. To prevent the assembly from being brazed to the fixture, it has been found useful to coat areas on the fixture with sodium fluoride. When short runs of a brazing job do not warrant the design of a fixture, soft nickel or Monel wire can be used to hold the assemblies during brazing.

Joint Design

The optimum design of joints for satisfactory dip brazing of aluminum is a lap joint. Experience has shown that it is possible to make consistently sound joints when clearances between mating parts are approximately 0.002

Table II—Properties of 61S After Various Types of Quenching

Quenching medium	Ultimate strength, psi	Yield Strength, psi (0.2% offset in 2 in.)	Elongation in 2 in., %
Cold Water	47,500	38,750	14.5
Boiling Water	45,550	37,400	14.8
Air Blast			
High velocity	45,550	37,000	14.8
Low velocity	33,950	25,400	12.0

Properties based on conducting age-hardening heat treatment one day after quenching.

Table I—Aluminum Brazing Alloys

Alcoa alloy	Type	Core Material	Brazing range, F	Thickness range, in.	Remarks
11	Sheet, coated, one side	3S	1,110–1,140	0.006–0.102	
12	Sheet, coated, two sides	3S	1,110–1,140	0.006–0.102	
21	Sheet, coated, one side	J51S	1,110–1,120	0.019–0.102	Can be heat treated*
22	Sheet, coated, two sides	J51S	1,110–1,120	0.019–0.102	Can be heat treated*
713	Sheet, all filler metal	....	1,130–1,140	0.007–0.102	
718	Wire, all filler metal	....	1,100–1,120	0.062–0.187	Color of wire blends with that of 2S, 3S, 52S, and 61S when anodized in chromic acid.

* J51S is heat-treated by quenching directly from the brazing temperature and age-hardening at 340 F for approximately 10 hr. If warpage or breakage occurs from such treatment, heat-treatment can be done in a separate operation. Solution heat-treatment at 960 F for 10–20 min is followed by quenching in cold or boiling water (depending on the straightness requirements) and then by age-hardening at 340 F for 10 hours.

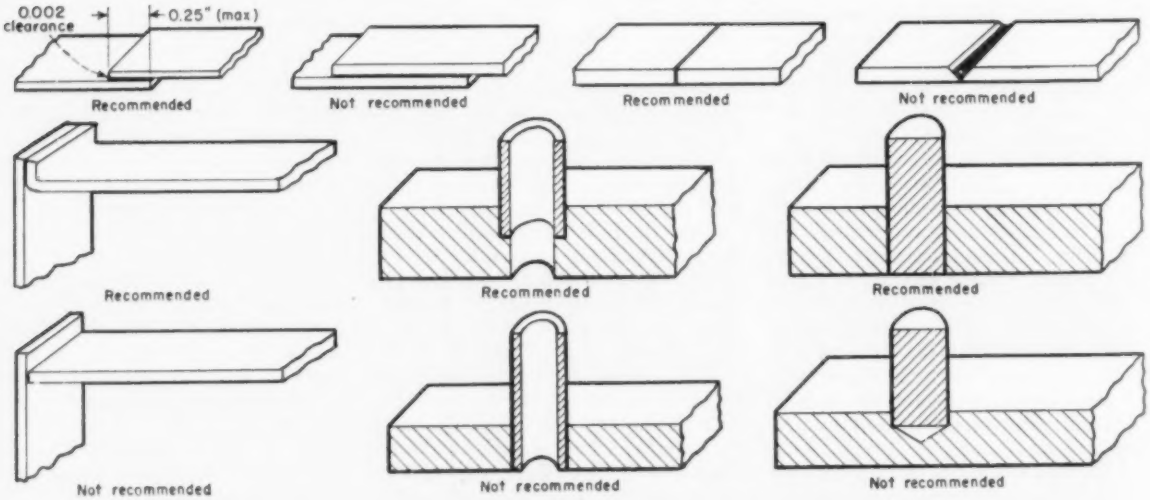


Fig. 2—Joint designs in which wire fillers are used, either as straight pieces or as preforms. Strip fillers can be used in long lap joints that approach one inch in length.

in. This spacing is satisfactory if the length of overlap at joints is not more than 0.25 in., as shown in Fig. 2. The shorter the overlap, the better, because flux entrapment is not apt to occur. In general practice, the length of overlap rarely exceeds one inch, but as the length increases, the clearance required to make a sound joint is necessarily greater. A clearance of 0.005 in. is sufficient for a one-inch overlap.

There are instances when, for functional reasons, a joint shown in Fig. 2 as "Not recommended" is preferable to a "Recommended" joint. The tube and flange joint, center Fig. 2, is a typical example. The lower of the two sectional views is "Not recommended" because there is a tendency for the filler metal to coat the exterior face of the flange thereby necessitating a machining operation to remove the excess metal. But in assemblies that require close dimensional control over the entire length of the ID, this joint configuration bonds along the OD down to the base of the flange. Upper sectional ("Recommended") design permits filler material to flow down the ID from the shoulder in the flange, again necessitating a special finishing operation.

Dip brazing of spot welded parts should be avoided because of the tendency for the faying surfaces to trap salts used in the cleaning solutions before brazing, and subsequently preventing satisfactory flow of filler metal. Similarly, it is difficult to dip braze hollow objects unless air can be vented readily as the part is immersed in the flux bath. The brazing of parts with blind holes should also be avoided because they tend to trap appreciable quantities of flux. These considerations emphasize the importance of designing and positioning joints so that flux is free to flow to and from the joint.

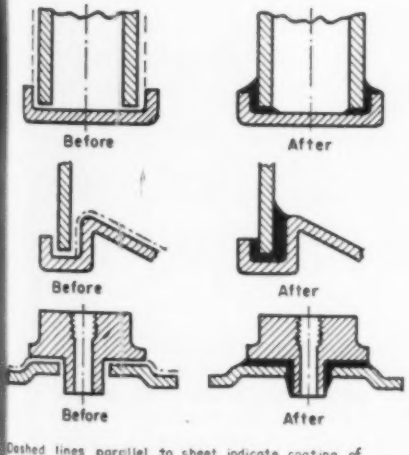


Fig. 3—Dip-brazed joints showing use of filler-coated aluminum sheet

Filler Alloys

The aluminum alloys used in dip brazing should be carefully chosen. This applies as much to the base metals as it does to the filler alloy. In addition, it is important to consider the form in which the filler alloy is used. The filler can be wire, strip or cladding on a higher-melting base metal. Selection of the best form for a particular job is not critical, but, for optimum joint quality, it should be made on the basis of the configuration of the assembly. Unfortunately there is no choice of wire or sheet alloys according to melting temperature, because there is but one alloy in each form. However, there are several clad alloys, Table I, for which the brazing temperatures differ to some degree.

Among the factors to be considered in choosing the form of the filler alloy are whether the filler can roll or fall from its preplaced position, whether on melting it can easily flow away from the joint area instead of into the joint, and what the joint clearances are. The judicious use of brazing alloy clad on a base metal such as 3S or J51S (see footnote, Table I) permits the assembly of parts with the brazing alloy available in the joint area, Fig. 3, thus assuring a completely filled joint. Any of the filler metals listed in Table I produces a joint having a tensile strength of 20,000 psi, average.

Wrought Aluminum Alloys

Of the commercially available wrought aluminum alloys, several heat-treated and work-hardened alloys are suitable for dip brazing. The most suitable of the heat-treatable alloys are 61S and 53S; the work-hardening alloys adaptable to brazing are 2S, 3S, 52S and 150S. Parts made of the latter alloys must function in the annealed condition, because the pre-heating temperatures of 950 to 1,000 F, followed by brazing at 1,100 F, usually anneal the metal. When it is required that dip brazed assemblies have high mechanical properties, it is necessary to use a heat-treatable alloy such as 61S. The proper heat-treatment of this alloy normally requires heating at 920 F for 20 min, quenching in cold water and age-hardening at 350 F for 8 hr. When the design of the brazed assembly is such that distortion may occur on quenching in cold water, boiling water can be used in the quench, resulting in somewhat lower mechanical properties after age-hardening. If the design of the assembly does not permit quenching, the parts can be cooled in a stream of air. The properties of 61S resulting from the various types of quench are shown in Table II.

Table III—Age-Hardening Schedule for Casting Alloys

Al-Zn-Mg alloy	Age-hardening temperature, F	Time, hr
40E	355	10
A612	220	4
Ternalloy 8	250	14
Tenzalloy	390	8

Casting Alloys

Most of the commercially available aluminum casting alloys are not suitable for dip brazing because of their low solidus temperatures, their melting temperatures being in the same general range as those of the brazing filler alloys. However, there are casting alloys that can be dip brazed and these are classified as the Al-Zn-Mg Types shown in Table III. They are characterized by somewhat higher shrinkage and lower fluidity than the more common aluminum casting alloys. The advantage of these alloys for brazing is that their solidus temperatures are generally, but not necessarily, higher than the liquidus temperatures of the filler metal alloys. But in cases where this factor of safety is not present, the small amount of liquid phase present at the brazing temperature is insufficient to cause difficulty. After the brazing operation is completed, an Al-Zn-Mg casting alloy can be restored to high strength either through a low-temperature aging heat treatment (Table III) or by aging at room temperature for three weeks. The post-aging properties and melting temperatures of these alloys are shown in Table IV.

Table IV—Post-Aging Properties of Casting Alloys

Al-Zn-Mg Alloy	Solidus temp, F	Liquidus temp, F	Tensile strength, psi	Yield strength, psi	Elongation in 2 in., %
40E	1,160	1,200	35,000	25,000	5.0
A612	1,130	1,210	35,000	31,000	2.0
Ternalloy 8	1,060	1,180	36,000	37,000	1.5
Tenzalloy	1,060	1,190	35,000	25,000	4.5

Elastic Elongation Of Chains

L. H. WHITNEY AND P. M. MacDONALD
Whitney Chain Company

CHAINS ARE SUBJECT to two types of elongation, elastic and plastic. Plastic elongation is a permanent set that usually occurs during the first heavy pull on any new chain. After the initial break-in period, there is no further plastic elongation unless the transmitted load causes yielding of the individual elements.

Elastic elongation is not confined to the initial loading period, but exists whenever there is load being applied. On a qualitative basis, designers have long recognized the value of this elastic property in cushioning shock between driving and driven shafts. Conversely, the need for take-ups and preloads to reduce slack caused by this elongation has also been recognized.

Quantitatively, however, there have been little or no data available. For this reason, the results of many tests extending over a considerable length of time have been compiled and developed into chart form. These charts are the summation of averages and limits computed for each individual chain size by statistical quality control methods. Although the elastic properties of a specific chain are functions of the material, part, and assembly dimensions, the limits for individual sizes do not differ greatly from the curves shown. Not more than 5 per cent of the chain manufactured in a given pitch will vary from its average by more than ± 0.014 in. at the 50 percent load point shown in the graphs at the right.

The maximum, average, and minimum elastic elongations for all sizes of ASA finished steel roller chain are shown in Fig. 2. This set of curves can be used for all pitches since the elastic elongation is nearly a straight line for this type of chain and the average ultimate strength is directly proportional to the square of the pitch. A commonly accepted formula for this relationship is:

$$(\text{Aver. Ult. Strength} = 14{,}500 \text{ lbs} \times (\text{Chain Pitch})^2.$$

To compare the elastic properties of conveyor and cable types, with those of ASA roller chain, the results of tests made with these types have also been included. Only average elongation values are shown. Since the tests were limited in number, it was impossible to predict accurately the maximum and minimum elongation values.

The average elastic elongation for double pitch conveyor chain can be found from Fig. 3. This type has standard rolls, pins, and bushings as used in ASA roller chain but these are assembled in side link plates having twice the pitch of the latter. They generally have heavier link plates, equal to those of ASA heavy series and the plates are of oval rather than figure eight contour. Their average ultimate strength is equal to that of ASA roller chain of one half their pitch. As in the previous case, one curve suffices for all pitches in this series.

Data for cable or leaf chains are given in Fig. 4. These consist of pairs of link plates alternately laced on pins. They can be made with 2, 4, 6 or more link plates in each pitch. The three curves show average elastic elongations for 2 x 2 (two plates in each pitch), 4 x 4 (four plates in each pitch) and 6 x 6 (six plates in each pitch) width

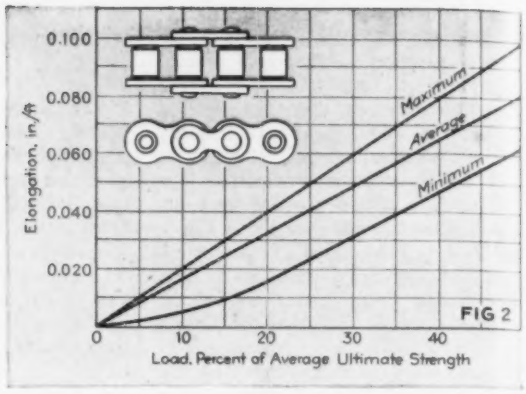


FIG 2

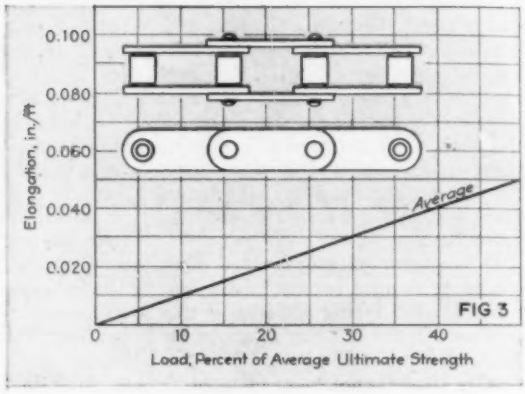


FIG 3

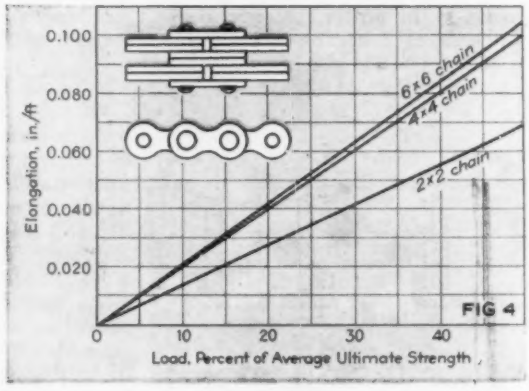


FIG 4

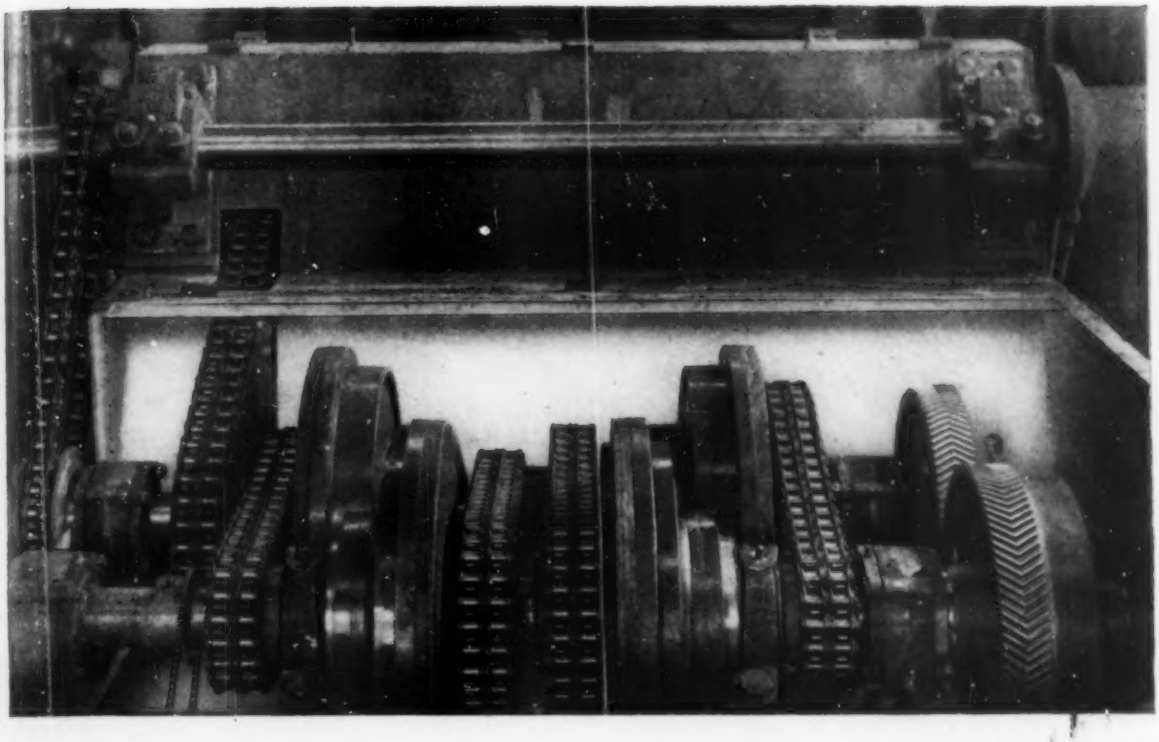


Fig. 1—(Above) Although chain drives effectively cushion shock loads in this four-speed compounding transmission used on oil well drilling rigs, numerical data for the elastic properties responsible for this characteristic have not been made available previously.

Fig. 2—Elastic elongation of single strand ASA finished steel roller chains of all sizes. Data were taken from extensive tests over a long period of time.

Fig. 3—Average elastic elongation of single strand, double pitch conveyor chain. Curve can be used for all sizes of chain without significant errors.

Fig. 4—Average elastic elongation of cable chain of various widths. These tests were not extensive enough to predict the maximum and minimum values.

Table I—Avg. Ultimate Strength and Elongation of Chain Drives

Chain Pitch, in.	Theoretical Ultimate Strength, lb			Average Elastic Elongation, in. Per Ft. at 50 percent Avg. Ult. Load.		
	ASA Roller Chain	Double Pitch Conveyor Chain	Cable Chain 2 x 2	ASA Roller Chain	Double Pitch Conveyor Chain	Cable Chain 2 x 2
3/8	2,200	—	2,200	0.081	—	0.069
1/2	3,620	—	3,620	0.081	—	0.069
5/8	5,660	—	5,660	0.081	—	0.069
3/4	8,150	—	8,150	0.081	—	0.069
1	14,500	3,620	14,500	0.081	0.050	0.069
1 1/4	22,700	5,660	22,700	0.081	0.050	0.069
1 1/2	32,600	8,150	32,600	0.081	0.050	0.069
1 3/4	44,400	—	44,400	0.081		0.069
2	58,000	14,500	58,000	0.081	0.050	0.069
2 1/2	90,600	22,700	90,600	0.081	0.050	0.069
3	—	32,600	—	—	0.050	—

chains. There are always minute differences in plate pitches and the length of each pitch will be governed by the shortest link plate in that pitch. This condition probably causes the differences in elongation of different widths, although theoretically all widths should have the same elongation at the same load expressed as a percentage of the average ultimate strength.

The theoretical average ultimate strength for chains in Fig 2, 3, and 4 are given in tabular form. The elastic elongation at 50 percent average ultimate strength is also shown. For loads of less than 50 percent of ultimate strength, the elongation can be found by simple proportion. An inspection of Table I shows that ASA roller chain has the most elasticity for its strength, so this type should be best for applications involving shock loads. Since double pitch conveyor chain shows the least elasticity, it is well suited for long conveyors where slack may be troublesome. Cable chain, with its high strength per unit width and its medium elastic qualities, is well adapted to weight lifting or non-rotating applications.

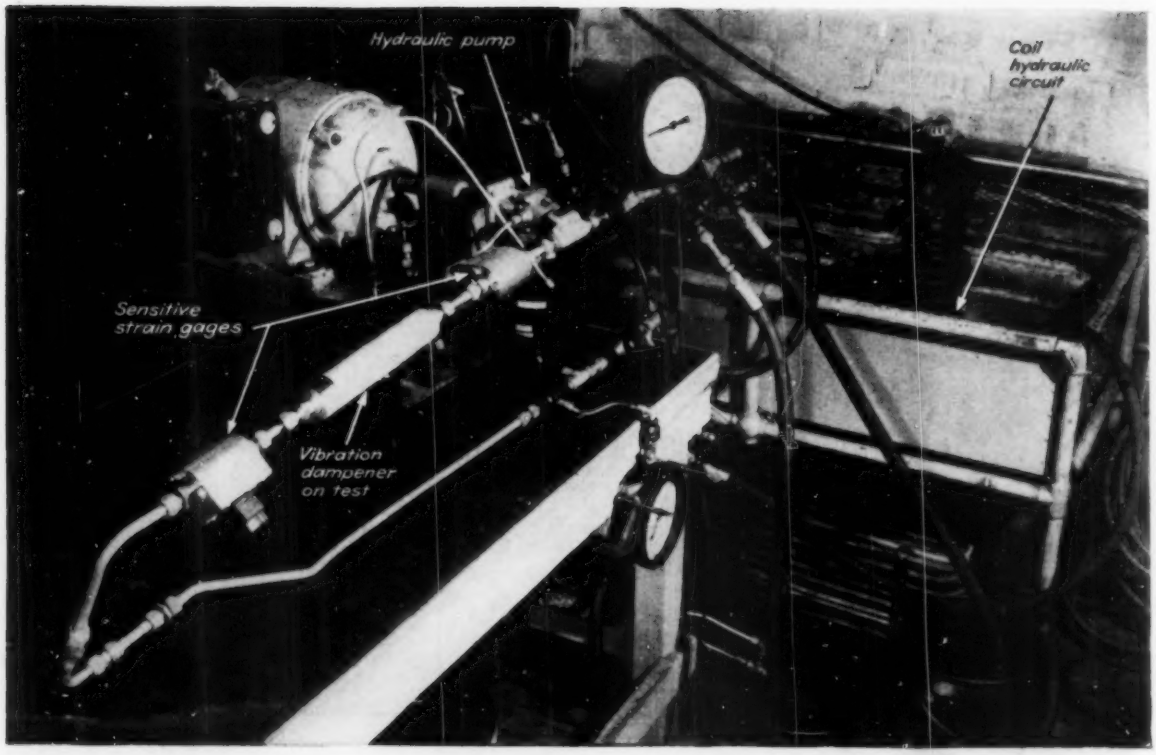


Fig. 1—Set up used at Lockheed to test various methods of reducing noise in hydraulic systems. Changes in pump wave characteristics were measured on oscilloscopes connected to sensitive strain gages in the discharge line.

Hydraulic Noise Reduction by Piston

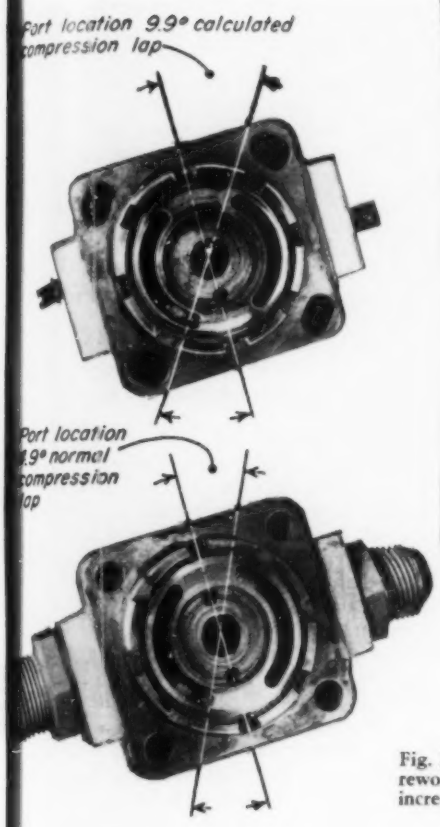
G. W. LOUTHAN
Mechanical Research Department, Lockheed Aircraft Corp.

NOISE IN HYDRAULIC SYSTEMS has passed beyond the stage of being a mere nuisance. Increases in operating pressure and a steady growth in circuit complexity have led to the incidence of more serious effects. It is not sufficient to reduce the hydraulic noise for personal comfort, although this matter deserves all the attention it has received in point of improved system mounting, practical isolation of local noise sources, and similar improvements.

A more fundamental trouble arises from the excessively high rates of pressure change, of which the noise is the outward token. Such high rates involve correspondingly high forces, however localized, and there can be little doubt but that these forces play a distinct part in the service deterioration of hydraulic systems. The fundamental problem is to eliminate or at least to reduce the disturbances at their source.

Axial flow piston type hydraulic pumps and motors, which are the chief source of repetitious high pressure rates, function by transfering discrete parcels of fluid from one pressure state to another. The process is one of filling a cylinder at one pressure, connecting it to another region at a different pressure and then discharging the cylinder. In a pump, this means that a cylinder of oil at a low pressure is more or less abruptly connected to a system of oil at high pressure. In the fleeting process of pressure equalization, oil surges into the cylinder from the system, thereby propagating a reduced pressure wave throughout the system, followed at once by a positive pulse as the local fluid motion is checked and reversed by elasticity. For a motor, the same general thing occurs, with the sign reversed for pressure pulses. At the inlet port, a similar occurrence takes place but on a much reduced scale, since there the minimum (clearance) volume of oil is involved.

Measured on an energy basis, 90



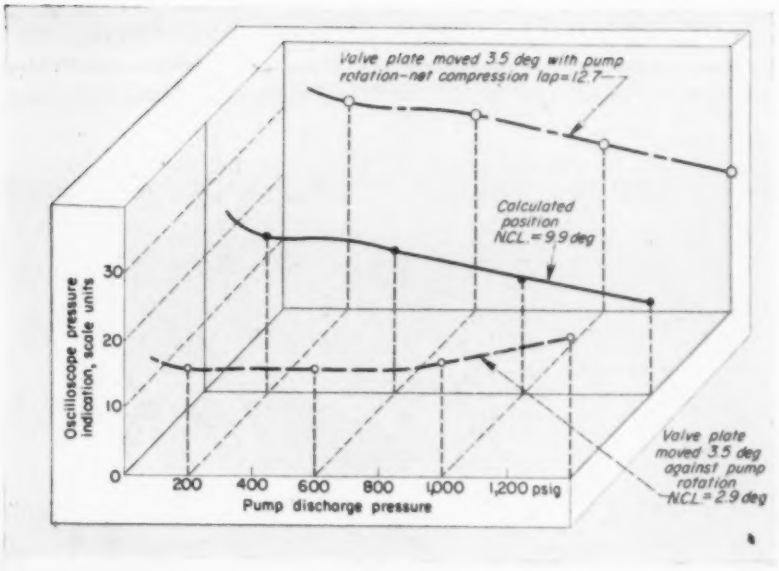


Fig. 3—The curves above are plotted on a three dimensional graph and show the relationship between port wave intensity, the net compression lap of the valve plate and discharge pressure. The middle line should reach its minimum at about 1550 psi.

Fig. 2—Piston pump valve plates. The valve plate at top has been reworked by filling in part of the crescent shaped discharge port to increase compression lap. This decreases the pressure change rate.

Pump Modification

Measured on an energy basis, 90 percent of the noise in a circuit can be reduced by pump modification. First of three articles on hydraulic noise.

percent of the noise in hydraulic systems may be eliminated at the source by including in the design of the pumps and motors provisions for precompression of the hydraulic fluid before discharging it into the high pressure line. As shown here, a design change on pump and motors to reduce pressure wave amplitude is the most direct solution to reduction of noise in hydraulics systems and entails little weight and no fundamental change in pump mechanics or geometry.

To examine the potential energy changes incurred by one cylinder of liquid in passing through an axial piston type hydraulic pump, let:

P_n = Pump inlet pressure, psi.
P_d = pump discharge pressure, psi.
V_c = swept volume of each cylinder, cu. in.
V_0 = clearance volume of each cylinder, cu. in.
K' = adiabatic bulk modulus of liquid elasticity, psi.
= 180,000 psi derived from acoustic velocity tests and represents nominally bubble free oil (pressurized oil)

In passing from inlet to discharge, the change in liquid volume is:

$$\left[\Delta V\right]_n^d = \left(\frac{P_d}{K'} - \frac{P_n}{K'}\right)(V_c + V_0)$$

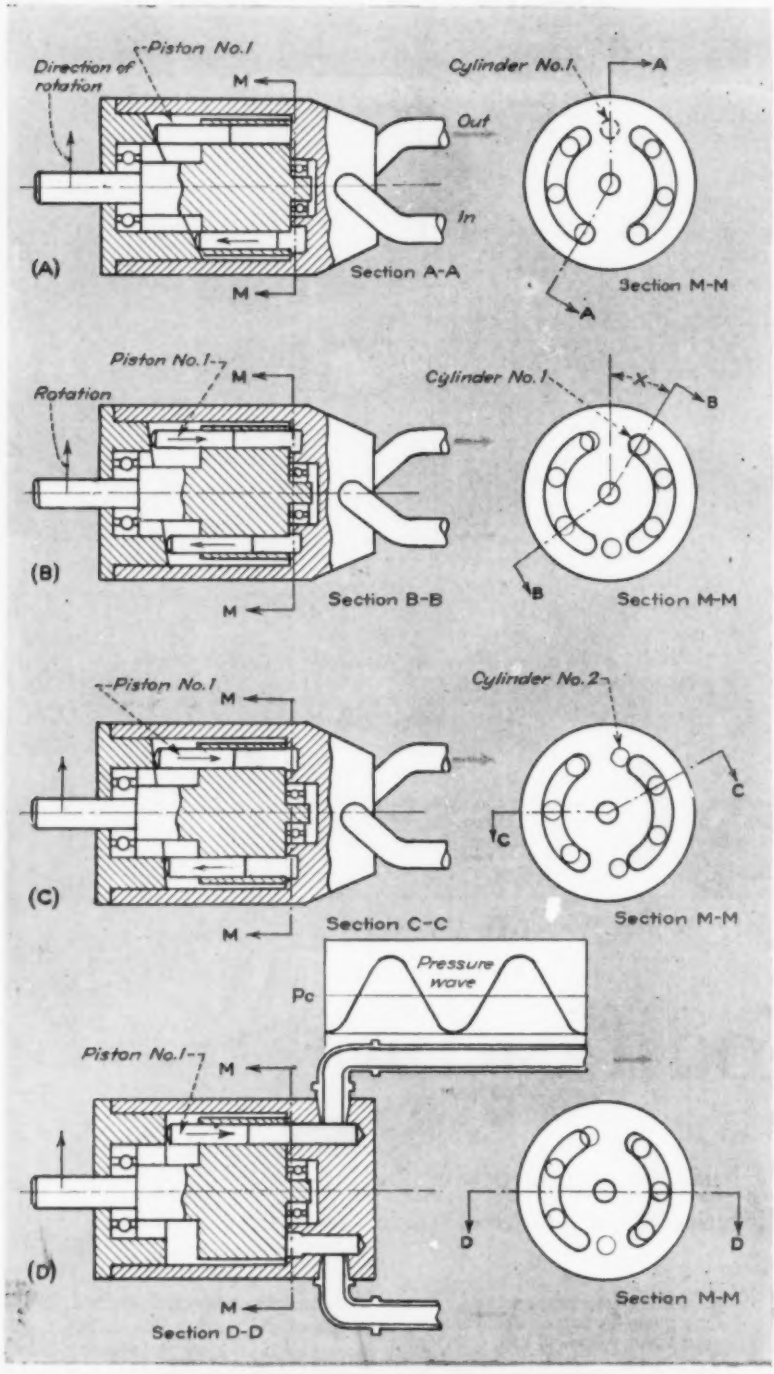
$$= \frac{(P_d - P_n)(V_c + V_0)}{K'}$$

Assuming no material change in the value of K' during the transfer, the parcel of liquid is a fluid spring, taken from an initial to a final state of strain. The change in potential energy equals the work done between initial and final states. This is the product of displacement and mean force during displacement. With constant spring rate

$$\Delta(P.E.)_n^d =$$

$$\frac{(P_d - P_n)(V^0 + V_c)}{K'} \times \frac{P_d + P_n}{2}$$

$$(P_d^2 - P_n^2) = \left(\frac{V_c + V_0}{2\,K'}\right) \qquad (1)$$



while for the return of that cylinder from discharge to inlet conditions,

$$\Delta(P.E.)\frac{n}{d} = (P_d^2 - P_u^2)\frac{V_0}{2K'} \qquad (2$$

These quantities are distinct from the mechanical work involved in promoting flow at discharge pressure; that is, normal pump work. They represent a work residue, positive or negative, which is stored elastically in the fluid incidentally to its change in pressure. These elastic changes in the fluid occur outside of a pump or motor, as the design of such units does not allow expansive use of the fluid. Thus it is that hydraulic noise originates at pump or motor ports and the wave energy is drawn solely from the elastic strain of the fluid.

Furthermore, as eqs. (1) and (2) indicate, the available wave energy is proportional to the difference of squares of the absolute pressures existing at opposite ports. Since actual wave energy is also proportional to the square of the pressure amplitude, the implication is that the pressure amplitude of port waves from pumps varies nearly directly with discharge pressure, because pump inlet pressure is usually low, both absolutely and in relation to discharge pressure.

The foregoing is a greatly simplified statement of the case, in that it is premised upon a homogeneous liquid, zero leakage across ports and an instantaneous discharge. None of these conditions exists in actual service, but the theory checks fairly well with experiments. The main disparities between the effects of an idealized noise source and those of a real one are:

1. Actual wave amplitude does not rise as rapidly, with increasing discharge pressure, as has been suggested. This is due partly to leakage; partly to the rapid rise of internal damping, both in fluid and tubing; and partly to the characteristics of real wave form.

2. Actual wave amplitudes may be considerably higher, under any service condition, than the simple theory values. This is due to the presence.

Fig. 4—Production of Port Wave in Standard Pump. (A) Piston No. 1 has completed the inlet stroke and the cylinder cavity is full of oil at inlet pressure. (B) Oil in cylinder No. 1 is suddenly exposed to the high pressure oil of the discharge line and oil surges back into cylinder in effort to balance the difference in pressures. This high pressure front is shown moving into cylinder. (C) Inertia of the oil surging back into the cylinder causes supercompression of the oil in the bottom of the cylinder and the elastic fluid is stressed as a compressed coil spring. Simultaneously, reverse flow reduces the local discharge pressure producing the negative impulse of the port pressure wave. (D) The positive impulse of the port wave is generated when the cylinder oil reacts from the compressive stress shown in (C) and sends a surge of oil into the discharge line at extremely high pressure. For theoretical analysis, the oscillations thus produced are considered as simple sine waves. Actual port waves are complicated by minor pressure differences during the last part of discharge and the first part of inlet strokes. The frequency of a port wave path produced by a hydraulic pump of this type depends upon its speed of rotation and the number of cylinders.

in the fluid, of appreciable amounts of free air, which profoundly affects wave generation. The allusion here is not to gross and obvious cavitation, but rather to a condition of the oil which no feasible amount of supply tank pressurization can prevent.

There are two ways to reducing port pulses:

1. Reduce the pressure change experienced by the fluid in leaving or entering the cylinder (pre-compression);

2. Increase the time for pressure changes to occur (balancing leak). The possibilities in the latter method are more easily appraised, so it will be studied first.

As shown in the following analysis the minimum pressure rise rate $(dP/dt)_m$ remains high enough for knocking to occur, and excessive leakage causes loss in pump efficiency. These conclusions have been fully confirmed by experiment.

Let:

D = pump displacement, in 3/rev.
n = number of cylinders
N = RPM
ΔP = pressure difference across pump
K' = adiabatic elastic modulus of oil
θ = lap angle through which pump shaft turns, measured from dead center to initiation of discharge, in radians
t_1 = leakage time, seconds

Estimating cylinder clearance to be 10 percent of swept volume, these relations appear:

Total volume/cylinder = $V_c + V_0 =$

$$1.1\,\frac{D}{N}\ \text{in.}^3$$

Flow required to equalize cylinder and discharge pressures,

$$\Delta V = 1.1\,\frac{D}{n}\cdot\frac{\Delta P}{K'}$$

Time available for pressure equalization,

$$t_1 = \frac{60}{N}\cdot\frac{\theta}{2\pi} = 9.55\left(\frac{\theta}{N}\right)$$

The flow (ΔV) must occur in the interval (t_1).

The mean rate of pressure change

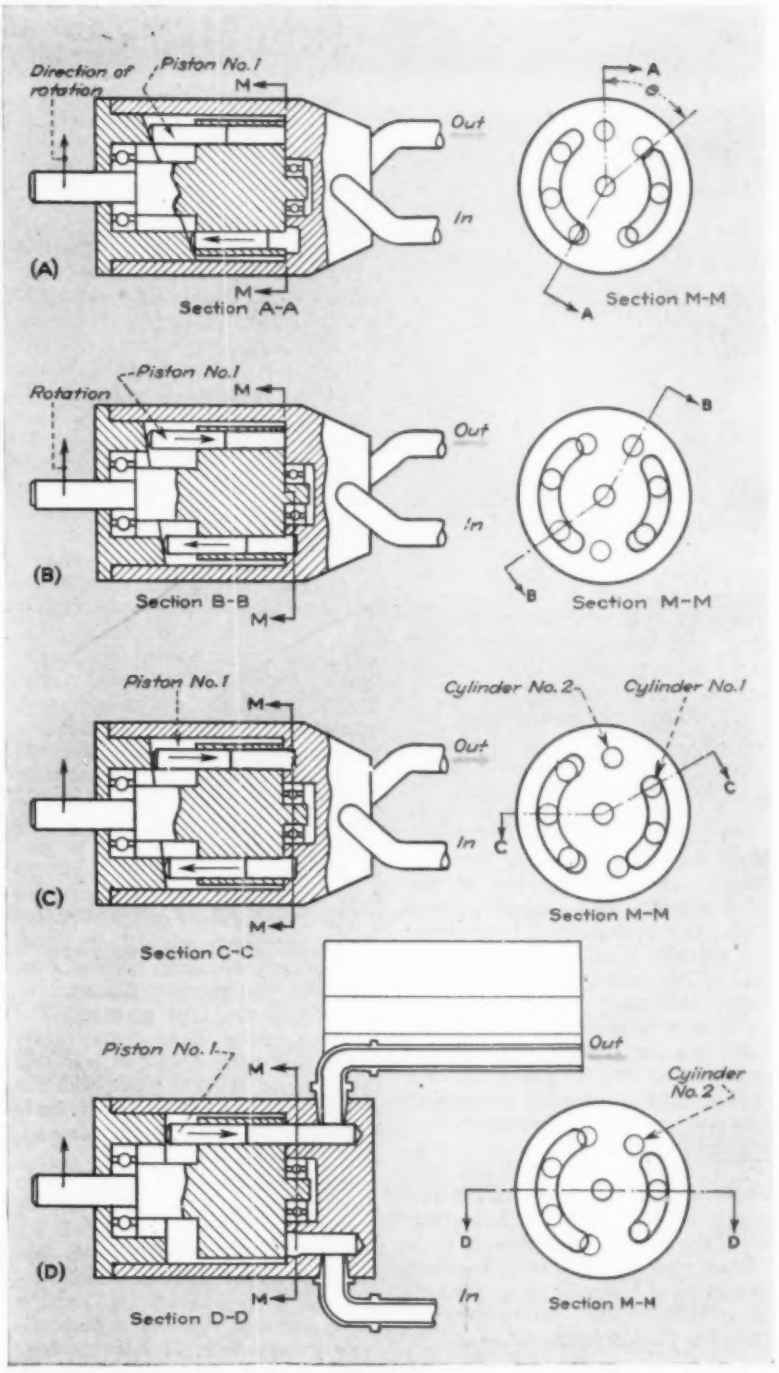


Fig. 5—Reduction of Port Wave by Precompression. (A) After passing the inlet port, cylinder no. 1 is full of oil at inlet pressure and piston is at bottom center. (B) The piston has passed bottom center, started back into cylinder and is reducing the cylinder volume. However, the cylinder has not yet been opened to the crescent shaped discharge port and the fluid in the cavity is being compressed. The number of degrees compression lap (θ) required to produce a desired precompression depend upon pump speed and condition of fluid. (C) When the cylinder full of pressurized oil is exposed to the oil of the discharge line the pressures of the two parcels of fluid are approximately equal and no local fluid flow is necessary. No moving pressure front is possible. (D) With local reverse flow checked normal pump discharge is constant and port wave amplitude is reduced to a minimum. Precompressing does not impose an extra load on the pump nor does it require more power. It actually anticipates work that normally would be done in the lines or at the hydraulically actuated equipment. Experiments conducted at Lockheed Research Laboratories show that precompression designed in a pump does reduce port wave amplitude to well below the dangerous level.

within the cylinder is:

$$\left(\frac{dP}{dt}\right)_m = \frac{\Delta P}{t_1} = 0.105\ \frac{(\Delta P)\,N}{\theta}$$

To show the implications of this, a numerical example may be drawn from a pump running, at 1750 RPM, 1200 PSI (ΔP) and a flow of 4.545 GPM. The above quantities become:

$V = 0.000628$ in.^{3}
$t_1 = 0.000131$ sec.

giving

$$\left(\frac{dP}{dt}\right)_m = 9{,}150{,}000 \text{ PSI/sec.}$$

while

$$Q_l = \frac{\Delta V}{t_1} = 4.8 \text{ in.}^3\text{/sec.} = 1.25 \text{ gpm}$$

mean leakage flow rate.

This is leakage of 27.5 percent of pump displacement. This leakage reduces pump efficiency in proportion and the pressure change rate is still extremely excessive.

Manipulation of cylinder pressure, instead of time, gives a much better approach to the problem in at least two practical respects:

(a) Pump leakage is reduced, not deliberately increased;

(b) The pump alteration is much easier to calculate and to make.

The essence of this method for abating pump noise lies in pre-compression of the fluid before exposing it to discharge. The discharge lap of the valve system is increased enough to apply such pressure and to perform the requisite elasticity work on the fluid. This is not extra work, but merely anticipated work. The prime virtue of pre-compression is that cylinder pressure change rates are put under control and are greatly reduced by the pump (or motor) kinematics. As shown in Fig. 12, the only change required in piston type pumps or motors is to increase the inter-port seal length on the entering end of the discharge port, for pumps, or the leaving end of the inlet port, for motors.

Based upon the substantially correct assumption of harmonic piston motion, the calculation of pre-compression takes this simple form. Letting:

x = piston movement from back center, during compression
r = half of full piston stroke
θ = angle turned by pump shaft, from back center position
a = piston area

Then,

$$\frac{\Delta V}{V_c} = \frac{xa}{2ra} = \frac{ra\,(1 - \cos\theta)}{2\,ra}$$

$$= \frac{1}{2}\,(1 - \cos\theta)$$

$$\Delta V = 1.1\ V_c\left(\frac{\Delta P}{K'}\right), \text{ allowing 10 percent clearance.}$$

$$\frac{\Delta V}{V_c} = 1.1\left(\frac{P}{K'}\right) = \frac{1}{2}\,(1 - \cos\theta)$$

$$\cos\theta = 1 - 2.2\left(\frac{\Delta P}{K'}\right)$$

$$\theta_c = \cos^{-1}\left(1 - 2.2\left(\frac{\Delta P}{K'}\right)\right) \qquad (3)$$

with (Θ_c) being the compression angle through which the pump shaft is to turn, from back center for any one piston until its initial connection to the discharge port. This is based upon zero original lap.

The valve plate for an experimental pump was reworked according to the foregoing. Tests of pre-compression benefit gave a direct comparison of port pulse intensity by using alternately a standard valve plate and the reworked one, on the same pump. Even with an inlet pressure of O PSI, giving mild cavitation, the value of pre-compression was indicated distinctly, while application of a representative inlet pressure of 25 PSIG gave the anticipated improvement. Fig. 3 summarizes the tests on a revised pump. The height of the oscilloscope trace, which is a linear function of port pulse pressure amplitude, is plotted against pump discharge pressure for a uniform inlet pressure of 25 PSIG. The isometric array of curves, connected by discharge isobars, is believed to give an adequate conception of a pump's behavior.

The *calculated net* compression lap in the test pump was 9.9 deg., corresponding to minimum noise at about 1550 PSI port pressure difference or 1575 PSIG discharge pressure. The middle one of these three curves shows that noise reduction was still being gained at 1400 PSIG, with the reworked valve plate and pump body in their normal relative angular position.

The foremost curve of the three shows the performance obtained by rotating the valve plate the full 3.5 deg. against rotation. All events thus occurred earlier; the admission lap increased from 1.4 to 4.9 deg. and the gross discharge lap was correspondingly reduced from 11.3 to 7.8 deg., giving a net compression lap of (7.8 — 4.9) or 2.9 deg. The calculated discharge pressure to match this new condition is 480 psi gage, which is seen to be entirely consistent with the shape of the curve under discussion.

It is worth note, however, that in this latter case about 15 percent greater amplitude of port noise was indicated, as compared with even the non-minimum condition of 1400 PSIG and neutral adjustment. The explanation is considered to be that with admission lap as great as 4.9 deg, appreciable forced cavitation occurred inside the charged cylinder as it crossed back center. This may well have disturbed the air content of the oil enough to give some air knock at discharge, since the degassing of a liquid by a pressure reduction is more rapid than the reversed process.

The rearmost curve on this sheet shows the effect of moving the valve plate 3.5° from neutral in the direction of pump rotation. The calculated discharge pressure to suit this is 2685 PSIG, so considerable noise occurred at the lower discharge pressures, with reversal of the usual pressure pulses.

Offhand, it might be supposed that compression lap would be distinctly beneficial at only one pressure. The slope of the middle curve, however, reflects the general observation that noise intensity changes are more gradual, with respect to discharge pressure trends, for the reworked valve plate than for the standard part. As previously derived, the port pulse energy is:

$$\Delta(P.E.) = E = (P_d^2 - P_n^2)\cdot\left(\frac{V_c + V^0}{2\ K'}\right)$$

For an unmodified pump, P_n is the inlet pressure or nearly such. Therefore, low values of (E) can occur only at low values of (P_d), the discharge pressure. But for a pump with compression lap, (P_n) is the cylinder pressure at discharge and on either side of the optimum condition ($P_d = P_n$) there exists an appreciable range of discharge pressure wherein (E) does not increase rapidly. In other words, the optimum lies in a wide valley, within which it is entirely feasible to contain the majority of the pump's operating pressure conditions. This makes the precompression method usable in most pump applications.

Where a pump is used that does not include provisions for noise reduction or operating conditions are too extreme for full effectiveness of the method given here, other precautionary measures should be taken to suppress the port wave as much as possible. Two of these measures are to be presented in the second and third articles of this series. These articles will appear in forthcoming issues of PRODUCT ENGINEERING.

Application of capacitive loading chambers to hydraulic systems will be explained in the second article. Capacitive loading chambers are spherical steel shells in which pump port waves can be dissipated. The third article, is on hydraulic fluid conditioning and explains how air affects noise propagation in hydraulic systems and how the effect can be reduced.

Phosphate Coatings for Military Products

Gun crew firing 155 mm coastal gun. A protective chemical film meeting specification MIL-C-5541 is used on many of the aluminum components in this gun. U. S. Army Photograph

A review of the types of phosphate coatings being specified by the armed services for protection of metal surfaces.

NORMAN P. GENTIEU, American Chemical Paint Company

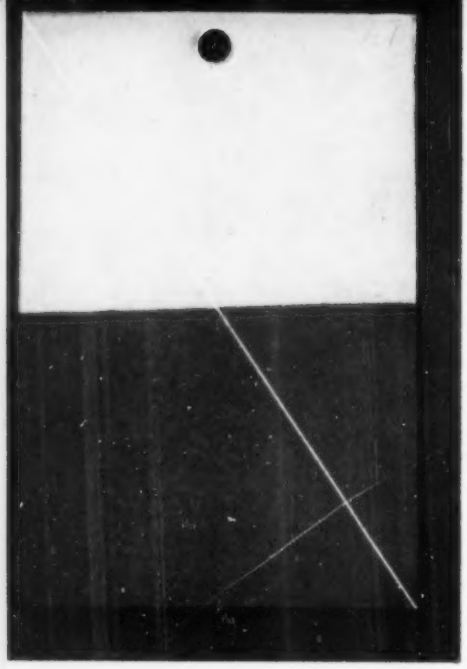
PHOSPHATE coatings are protective inorganic finishes that actually change the chemical nature of metal surfaces. The metal reacts with the applied phosphate solution to form a non-metallic, crystalline film. This film can:

1. Improve paint adhesion
2. Provide protection against corrosion
3. Increase lubricity of friction surfaces
4. Facilitate metal forming such as drawing and cold extrusion
5. Serve as decorative finishes on some products

As recently as World War II, a large proportion of military equipment was inadequately protected from corrosion. Evidence for this fact could plainly be seen about any Army or Navy installation. For this reason, designers concerned with the present defense program find many new and rewritten specifications calling for the protection of steel, zinc and aluminum surfaces by means of chemical conversion coatings, principally the phosphate coatings.

Essentially, phosphate coatings either serve as a foundation for decorative and protective organic finishes; provide a receptive and retentive surface for rust proofing treatment; or improve the lubricity of a rubbing or friction surface for "wear in." Whatever the objective, the principle of these protective finishes is the same. By a chemical reaction with the solution used in the treatment, the surface of the metal is changed to an insoluble, phosphate, chromate, oxide or other salt, which remains as a coating.

The extent to which conversion coatings are employed in the production of military equipment is best illustrated by an example. A fully protected army truck would have a zinc-iron phosphate finish under the paint. The pistons, if cast iron, would be coated with a manganese-iron phosphate layer; if aluminum, these would be anodized (anodically oxidized). The fuel pump, a zinc alloy die casting, would have a chromate coating sometimes topped with a clear lacquer. Assorted hardware such as nuts, bolts, pins and washers would bear a zinc or manganese base phosphate coating impregnated with a small amount of chromic acid and rust preventive oil. The camshaft, rocker arm and other reciprocating surfaces would be coated with manganese-iron phosphate.



Aluminum panel that has been protectively treated with chemical film as specified in MIL. C-5541. Top half of panel has zinc chromate primer only, over this chemical film, while bottom half has primer plus finish paint coat. When moisture contacts the primer, hexavalent chromium ions are released and this tends to neutralize any corrosive action. The protection afforded is in addition to the excellent corrosion resistance and improved paint adhesion provided by the original chemical film.

Types of Conversion Coatings

There are seven types of coating being specified today by military agencies:

1. Zinc-iron phosphate. This is the heaviest type of coating (grey in color) used for pre-paint treatments on steel, iron and zinc surfaces. The process requires five or six operations, including cleaning; rinsing; rust removal, if necessary; coating; rinsing and final rinsing. The coating weight ranges between 100 to 600 mg per square foot.

This treatment is specified for medium or large volume production items, such as automobile bodies, projectiles, small arms, rifles, cabinets and tanks.

The coating solution improves paint adhesion by forming a crystalline deposit over the metal surface. This deposit is rough, microscopically speaking, and so offers an ideal gripping surface to paint particles. The coating can be applied by spray, dip, flow or brush.

2. Manganese-iron phosphate. This is a heavy jet-black coating used on friction surfaces to prevent galling, scoring or seizing of parts. Typical metal products treated include pistons, gears, cylinder liners, camshafts, tappets and several small arms components.

The manganese-iron phosphate coating is applied by dipping and is suitable for large or small volumes of production. The coating weight range is 1,000 to 4,000 mg per square foot.

3. Iron phosphate is a fairly new development that places a light coating on surfaces for improved paint adhesion. Cleaning and coating occur in the same bath so the process can be carried out in three stage equipment. Quality results have been more erratic with this type of system and metal imperfections are more pronounced.

The iron phosphate treatment is a spray process and is suited for medium or large volumes; large or small work. Precleaning is normally unnecessary, an economic factor in favor of this treatment.

Typical products are steel or iron fabricated units, such as cabinets, washing machines and refrigerators. Weight of the coating is 50 to 100 mg per square foot.

4. Zinc phosphate is a crystalline coating produced on galvanized iron and other zinc and cadmium surfaces for improving paint adhesion. Object of the coating is to provide a paint-gripping surface.

This coating is applied by spray, dip or brush to a weight of 75 to 500 mg per square foot. There are no limitations on volume of production or size of products. Zinc phosphate coating is used on zinc alloy die castings, zinc or cadmium plated sheet or components, hot dip galvanized stock and galvanneal.

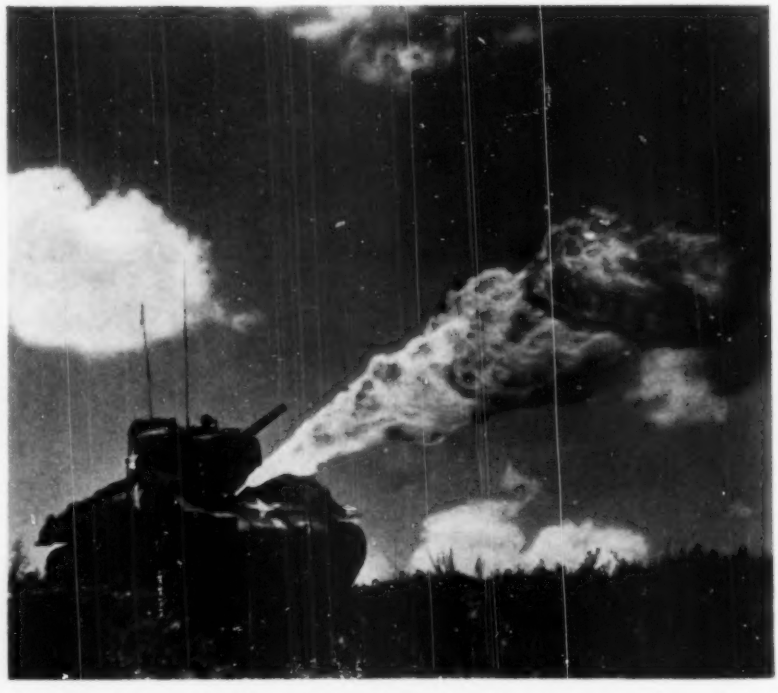
5. Amorphous phosphate is the prototype of the new protective chemical coatings for aluminum and aluminum alloys. These coatings may be used in place of anodic deposition for improved paint adhesion and corrosion resistance.

This coating is applied by brush, dip or spray and is practical for all volumes of production. Coating weight is 100-200 mg per square foot. Products treated include helmets, belt buckles, aircraft and aircraft parts, bazookas and rocket motors.

6. Zinc-iron phosphate (for oil absorption) is a relatively heavy coating adapted to the retention of rust-inhibited drying or non-drying oils and waxes to prevent corrosion of ferrous metal surfaces. The crystalline deposit acts as a sponge in holding the oil. The coating is applied by dipping to a weight of 1,000 to 4,000 mg per square foot.

The process is satisfactory for large or small volumes of large or small work. Products treated are nuts, bolts, hardware, guns, tools and others.

7. Zinc-iron phosphate (for metal forming). This is a specialized coating



Flamethrowing tank with radio equipped top turret hurls 40 yard jet of blazing oil. Tracks of tank and friction surfaces of engines are finished in manganese iron phosphating compound. This is an abrasion resistant, rust-proof coating which can be applied by tank dipping. Signal Corps Photo

used in conjunction with a suitable lubricant to facilitate the cold mechanical deformation of steel. A light zinc-iron phosphate coating acts as an anchor to the lubricant throughout drawing, extrusion and cold forming processes.

This is a successful treatment for products such as blanks and shells for cold forming; heavy stampings; extruded tubular shapes and drawn wire.

Formation of Coatings

In general, the mechanism of phosphate coating formation is as follows: The clean sheet of steel enters the coating stage of the process covered only with a light film of solvent, which promotes fine-grained crystal formation.

The first chemical change to occur on the surface of the steel is a pickling reaction. Iron is dissolved from the surface and the free acid in the solution immediately next to the surface is consumed. The removal of this free acid causes zinc phosphate to precipitate on the surface of the steel. This is because the solution immediately adjacent to the steel has become supersaturated with respect to zinc phosphate, which is more soluble in acid.

The iron dissolved in the pickling reaction slows down coating formation and must be removed from the bath. This can be done by the addition of hydrogen peroxide to the bath. This causes the iron phosphate to precipitate, making the dissolved iron insoluble. Thus, the undesirable ferrous iron is removed continually from the bath. Some of the iron phosphate is precipitated adjacent to the steel surface and becomes part of the coating.

When the ferrous iron is oxidized to the insoluble ferric state some phosphoric acid is liberated. The amount of free phosphoric acid present in the bath at any given time must be just right to obtain the proper degree of "super-saturation," which is the tendency for zinc phosphate to precipitate from the bath. This free acid is controlled by the addition of sodium hydroxide solution in carefully metered amounts, to the bath.

It is, thus, seen that finishing with phosphate coatings involves fairly complex chemical processes. The designer must, therefore, rely on the suppliers of the coating compounds to work out the detail specifications for the process itself. What is required of the designer is a knowledge of the performance characteristics of the various coatings and the surfaces they are suited for. In addition, the designer should be familiar with the amount of precleaning and after-rinsing needed for each type of treatment and the production equipment involved. Such information aids in choosing the most economical process for the job.

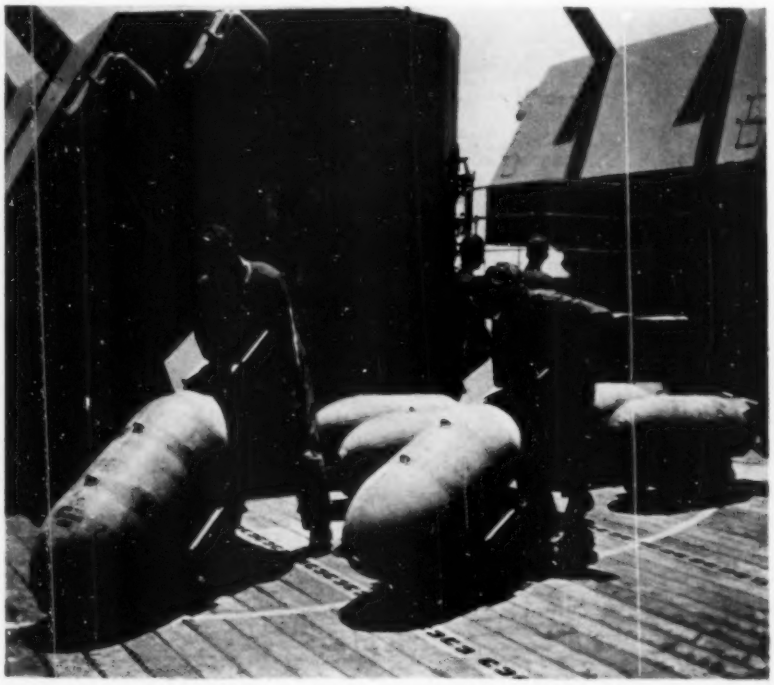
Improving Paint Adhesion

One of the primary uses for phosphate coatings is as an under layer for paints. A fine, inert, crystalline layer of zinc phosphate has electrical insulating properties. It affords excellent protection against galvanic corrosion by acting as an insulating sheet between the paint film and the active steel surface.

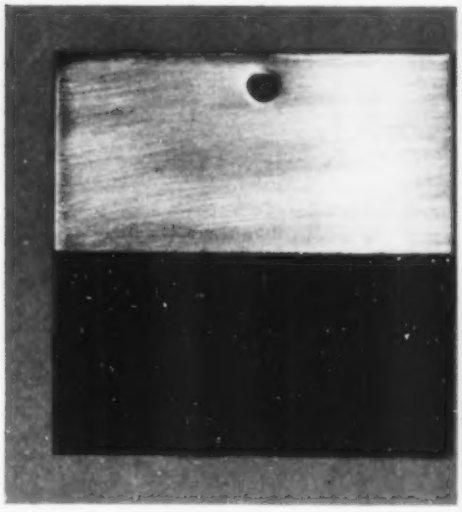
The tooth-like edge of the crystalline coating acts as a mechanical bond for the paint. The adherence of the coating to the steel is great because the coating, in the course of forming, becomes an integral part of the steel surface. In effect the treatment converts a portion of the steel's surface into coating. For this reason, these coatings are often called "conversion" coatings.

Steel and Iron

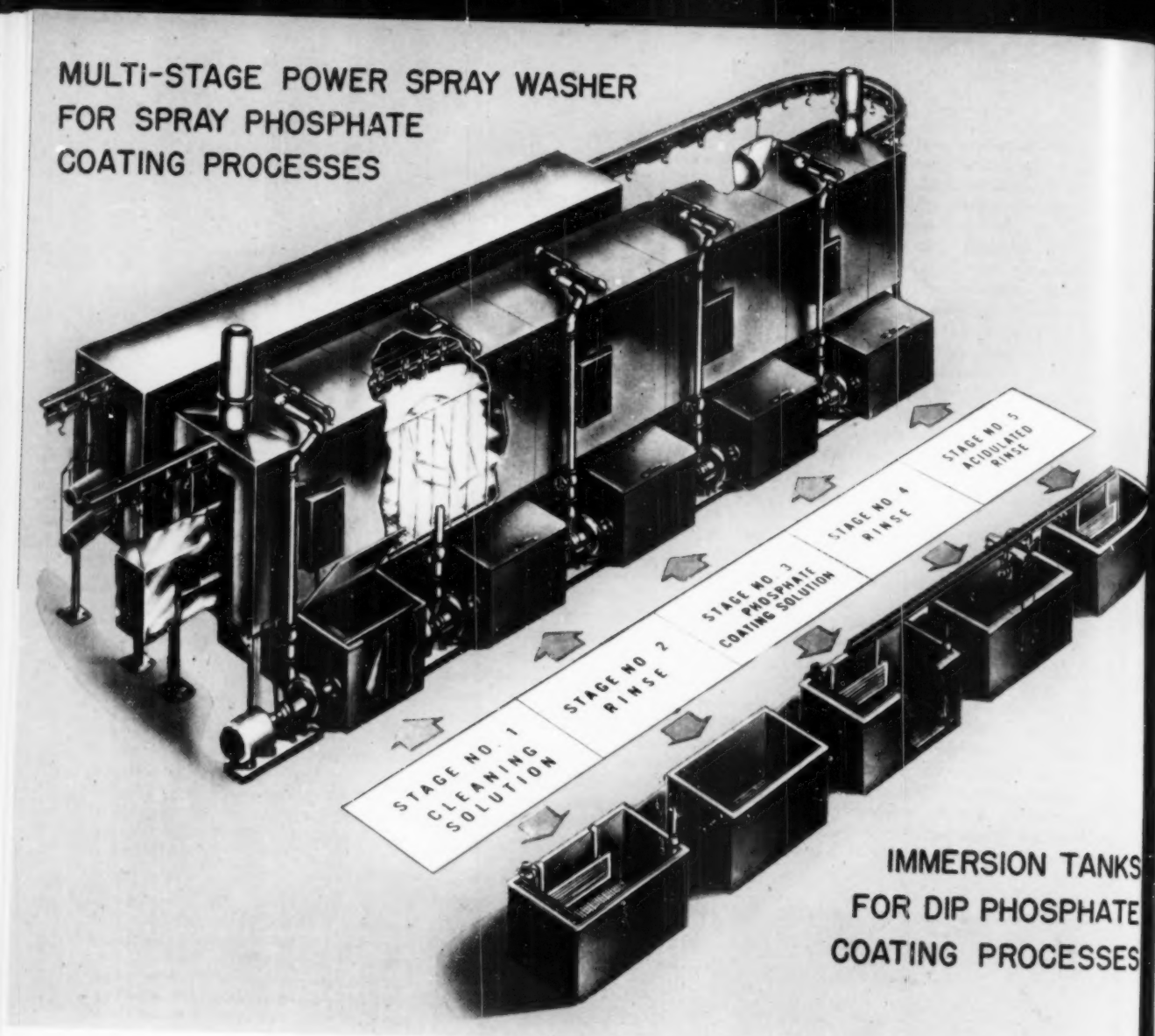
When steel and iron parts are phosphate coated to produce a Grade I Finish (Joint Army-Navy Specification Jan-C-490) or equivalent, a non-metallic crystalline layer of zinc phosphate forms on the surface. It is advantage-



Ordnance men aboard aircraft carrier stow 1,000 lb bombs. Metal surfaces of bombs are cleaned and prepared for organic coatings in accordance with Joint Army-Navy Specification JAN-C-490. Preparation includes treatment with zinc phosphate coating chemical for improved paint adhesion. Official Navy Photo



Test panel illustrates difference in appearance between untreated steel and steel that has been exposed to a manganese iron phosphate bath. Latter treatment is covered by Type II, Class A of U. S. Specification 57-0-2C. Phosphate coating is followed by application of rust preventative oil. Since phosphate coating is crystalline in structure it soaks up and holds oil for increased corrosion and wear resistance.



ous to zinc phosphate coat ferrous metal products because both the structure and the composition of the metallic surface are beneficially modified for paint bonding. The treated surface is inert, and composed of millions of microscopic crystals to which the paint finish is firmly anchored when dry. And, finish life is longer on phosphated steel than on untreated steel since phosphate coatings are non-metallic and non-conductive. The coating suppresses the destructive activity arising from galvanic corrosion. Rust or corrosion is restricted to areas where accidental scratching, denting, or chipping has exposed bare metal. The spread of rust or corrosion beyond the area of damage is greatly inhibited and retarded by the presence of a phosphate bond under the paint finish.

A zinc phosphate coating chemical is used to obtain a finish on steel meeting the requirements of Grade I of JAN-C-490, and equivalent specifications listed in Part II of the attached chart. This type of finish is now specified for projectiles, rocket heads, rocket motors, tanks, trucks, jeeps, containers for small arms, cartridge tanks, gasoline containers, shells, rockets, bombs, vehicular sheet metal, steel drums and many other products.

Depending on the size, nature, and volume of production, zinc phosphate coating can be carried out by spraying the parts with the various solutions in the successive stages of a power washing machine; by dipping the steel parts in the cleaning, rinsing and coating baths contained in tanks, or by brushing or flow-coating the work with portable hand equipment. In production, the complete zinc phosphate coating process consists of the following operations.

CLEANING
1—Cleaning
2—Rinsing
3—Removing rust (May be omitted when the parts are completely rust and scale-free)
4—Rinsing

COATING
1—Zinc phosphate coating (Grade I Finish, or equivalent)
2—Rinsing
3—Final acidulated rinsing

FINISHING
1—Drying
2—Painting

Each of the various Government Finish Specifications require that the phosphate coatings be subjected to salt spray tests. Details on these tests for various types of metal and final finish are given in Table I. In most cases the salt spray exposure is made after the final finish has been applied, but in others the phosphate coating itself is directly exposed.

Salt Spray Test Requirements for Phosphate Coatings Produced in Accordance with Government Finish Specifications

SPECIFICATION NO.	METAL TREATED	FINAL FINISH	HOURS OF S.S. EXPOSURE WITHOUT FINAL FINISH (WHERE REQUIRED)	HOURS OF S.S. EXPOSURE WITH FINAL FINISH
JAN-C-490, Grade I	Iron and Steel	Paint	——	250
U.S.A. No. 57-0-2C, Type II, Class C	Iron and Steel	Paint	——	250
U.S.A. No. 51-70-1A, Finish 22.02, Class C	Steel	Paint	——	250
U.S.A. No. 50-60-1D	Steel	Olive Drab Enamel	——	200
MIL-E-917A (Ships)	Ferrous Metal Surfaces	Gray Enamel	——	250
MIL-S-5002	Ferrous Parts	Paint	——	250
MIL-V-3329	Ferrous Metal Parts	Paint	——	250
JAN-F-495	Steel	Baked Enamel Coating	——	250
JAN-T-704	Steel	Paint	——	250
16E4 (Ships)	Ferrous Alloys	Paint	——	192 (frames and inclosure structures) 48 (other parts)
QQ-P-416	Cadmium	Paint	240-Class A 192-Class B 96-Class C	Not given
RR-C-82	Zinc	None	——	Not given
JAN-F-495	Zinc	Enamel	——	250
U.S.N. Appendix 6	Zinc	Paint	——	Not given
MIL-C-5541	Aluminum	Paint	168	500
MIL-S-5002	Aluminum	Paint	168	Not given
U.S. Navord O.S. 675	Aluminum	Paint	——	150
16E4 (Ships)	Aluminum	Paint	——	192 (frames and inclosure structures) 48 (other parts)
MIL-C-16232, Type II	Ferrous Metal Surfaces	Rust Preventative Compound	2	48
JAN-L-548A	Steel		——	48
U.S.A. 57-0-2C, Type II, Class B	Iron and Steel		2	36
U.S.A. 51-70-1 Finish 22.02, Class B	Steel		2	36
M-364	Steel		36	72
MIL-C-16232, Type I	Ferrous Metal	Rust Preventative Compound	1½	24
U.S.A. 57-0-2C, Type II, Class A	Iron and Steel		1	24
U.S.A. 51-70-1 Finish 22.02, Class A	Steel		2	36
M-364	Steel		36	72

Zinc and Cadmium Surfaces

Paint adhesion is poor on untreated or incorrectly treated zinc surfaces. In the past, many treatments were suggested for making paint stick to galvanized iron. Weathering for a period of several months prior to painting; etching with hydrochloric acid in toluol and alcohol; soaking in various solutions including salts of silver, ammonia, blue vitriol, sal soda, ordinary vinegar, and nitric acid were some of the measures tried. Unfortunately, not one of these provided the required action which is the insulation of the zinc surface from moisture and oxygen to permit the paint finish to adhere securely to the metal. Some treatments actually dissolved the zinc coating, so that when the paint peeled, the base steel was open to rust.

Paint films, regardless of quality or method of application, are porous. Paint applied directly to zinc with no intervening layer or film between metal and finish allows moisture, together with oxygen and carbon dioxide, to filter slowly through to the base metal. Here a chemical chain reaction takes place. Moisture combines with the zinc to produce normal corrosion products, such as zinc oxides and zinc carbonates. These salts in turn react with the fatty acids in the paint oils to form a chemical soap film which destroys the bond holding the paint. Eventually, the differential expansion of paint and metal causes peeling and exposes the protective zinc coating which has already been attacked and is now eaten away by atmospheric corrosion. This leaves the underlying iron and steel unprotected and free to rust. If, however, the zinc or galvanized iron surface is phosphate coated prior to painting, it can withstand all the normal rigors of weather without the peeling so characteristic of improperly prepared surfaces, military and civilian.

A zinc phosphate coating chemical is used to obtain a finish on galvanized iron and other zinc and cadmium surfaces that meets the requirements of typical specifications listed in Part III of the accompanying chart. Such specifications include QQ-P-416, RR-C-82 and JAN-F-495. This type of finish is dense, stonelike and continuous. It is now specified for cadmium plated parts, garbage and ash cans, electric power equipment for naval shipboard use and other products with zinc or cadmium surfaces.

A zinc phosphate coating can be applied by spraying, dipping, or brushing the chemical solution on the work. Weight of the coating ranges between 75 and 600 mg per square foot. Processing in a spray washer with at least five stages for cleaning, rinsing and zinc phosphate coating is suited to the finishing of either hot-dip or electro-galvanized sheets, coiled strip, or duplicate products rapidly and economically.

U. S. Army engineers prepare to fire a 37 mm fieldpiece. The finish of the breech mechanism of this gun is Type II, Class A of U. S. Army Specification 57-0-20. This is a manganese-iron phosphate coating containing a rust preventive oil. No paint is used. Small arms are similarly finished. 37 mm projectiles are protectively treated with Grade I Finish of JAN-C-490 (zinc phosphate coating) and then painted with enamel. U. S. Army Photograph

Zinc and cadmium surfaces including galvanized iron, galvanneal, cadmium plated steel, zinc plated steel, zinc base alloys and zinc base die castings can also be effectively phosphate coated in spray equipment.

Zinc phosphate solution used in tanks develops a paint-bonding coating on zinc and cadmium products that have been suitably freed from oil and rinsed. Die castings, cabinets and miscellaneous products fabricated from galvanized iron are typical of products which are best processed by immersion. The coated surface should be rinsed with a plain rinse and an acidulated rinse.

Brush application is required for some products. Included in this group are assembled structures, parts of buildings, naval vessels and their components, truck panels of galvanized steel or galvanneal, rain gutters, ventilators, metal road signs, galvanized fences, furnace ducts, transmission towers, hardware, metal specialties and venetian blinds. Because of the shape and/or bulk of such equipment the zinc cannot conveniently be coated by other means. A brush type of coating chemical is applied to the clean, paint-free surface and allowed to act for a minute or two. After this, the surface is rinsed, air dried and painted.

The steps involved in the protection of zinc and cadmium surfaces may be summarized as follows:

CLEANING

1—Cleaning (May be omitted if surfaces are free of oil and grease)
2—Rinsing

COATING

3—Zinc phosphate coating
4—Rinsing
5—Final acidulated rinsing

FINISHING

6—Drying
7—Painting

Aluminum Products

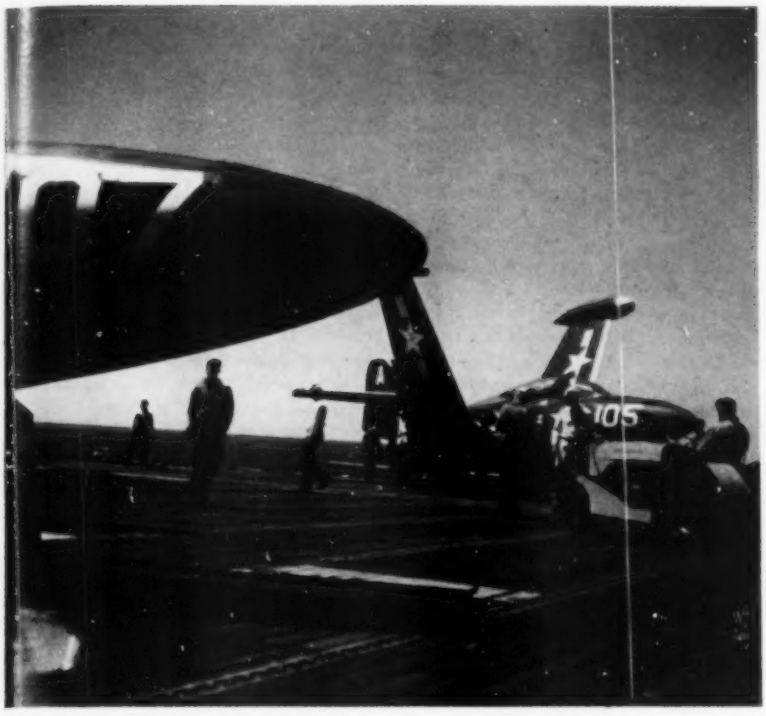
Untreated aluminum is subject to corrosion, consisting of the formation of the natural white oxide on the surface of the metal. The oxidation is most rapid when the metal is exposed unpainted to moist, salt-laden air or to a contaminated industrial atmosphere. Because of its reactive nature, aluminum is a poor base for paint unless the surface is actually changed prior to finishing. Even comparatively recently, aluminum airplanes have lost part or most of their paint finish during test flights soon after assembly. It is apparent that inadequate treatment of the metal is costly.

The ideal pre-treatment for aluminum accomplishes three objectives:

1. Cleansing of the surface of all traces of contamination and corrosion.
2. Protection of the metal from corrosion by forming an impervious, inert layer on the surface.
3. Provision of a sure and enduring base for paint.

Simple treatments involving cleaning, or etching or both do not change the chemical composition of the surface and are, therefore, inadequate. Far from retarding the corrosion of unpainted aluminum, such processes may in fact stimulate it. None of these treatments appreciably improves the bond or the protection of the paint finish.

In general, coatings integral with the aluminum itself have proved to be far more effective than cleaning and etching for bonding paint. These coatings fall into three main categories according to their composition: crystalline phosphate coatings; oxide coatings; and the newly developed protective chemical films, such as alodine, covered by such Finish Specifications as MIL-C-5541 and MIL-S-5002. In addition to substantial protection for unpainted aluminum—especially in moist and salt-laden atmospheres—this protective



Tractor aboard aircraft carrier swings a Grumman Panther F9F jet fighter into position. Aluminum surfaces of plane in the untreated state offer poor paint adhesion. Accordingly, specification MIL-C-5541 requires pre-paint treatment with amorphous phosphate coating to stop peeling. Official Navy Photo

coating provides an even better bond and more durable protection for paint than either conventional phosphate coatings or the laborious oxide-forming (anodizing) processes.

The protective coating chemicals listed in the qualified products list for specification MIL-C-5541 are used to obtain a finish on aluminum and its alloys meeting the requirements of this specification, and equivalent specifications. Data for these specifications are included in Part V of the chart following this article. This type of finish is now specified for naval aircraft; electronic equipment; cartridge powder, and rocket tanks of aluminum; ground signal equipment and other aluminum parts and products. The weight of the applied coating varies between 100 and 250 mg per square foot.

Essentially, the coating process consists of the following easily controlled operations:

1. Cleaning the work
2. Rinsing the cleaned aluminum surfaces
3. Coating the work
4. Rinsing with clean water
5. Rinsing with warm acidulated water
6. Drying

Aluminum parts that are to be protectively coated can be treated by immersion, or by spraying in an industrial washing machine. In general, small size products or parts are processed rapidly and conveniently in immersion equipment, which can be mechanized if production volume justifies it. For large-scale production of formed parts, or for treating coiled stock, strip, or cut-to size sheets, a five-stage power spray washer is most convenient.

Rust Proofing

Zinc phosphate coatings containing corrosion inhibitors are popularly known as "rust proof" finishes. Such finishes meet U.S.A. 57-0-2C; Type I, Class B, and equivalent requirements of other specifications listed in Part IV of the chart. They are for use on non-moving parts only and are substantially dry to touch. According to specification requirements, these finishes must withstand two hr of salt spray exposure when unoiled, and 36 hr of salt spray exposure when treated with a suitable oil.

To obtain a Class B finish, the properly cleaned articles are immersed for not less than 30 min in a hot, balanced phosphate rust-proofing solution containing nitrate as an accelerating agent, until a uniform crystalline phosphate coating is formed. The immersion time must be increased to one hour if a hot, dilute phosphate solution without an accelerating agent is used. After the dip, the parts are immediately rinsed in clean water, followed by a second rinse in a controlled dilute chromic acid or phosphoric acid solution. The rinse assures maximum corrosion resistance and minimizes the tendency of applied paint films to blister under conditions of high humidity.

A Class B finish is now required for metallic belt links, fire control instruments, steel aircraft parts, certain steel projectiles, mines, bolt assemblies, automotive hardware and instrument parts, and on various hardware items as a substitute for cadmium or zinc plating. Coating weight ranges from 1,000 to 4,000 mg per square foot.

Depending on the size of the parts, Class B zinc phosphate coating can be carried out by dipping the steel or iron parts in the cleaning, rinsing and coating baths contained in tanks, or by treating small parts in tumbling barrels. The steps required for rust-proofing are as follows:

CLEANING

1. Removing grease, oil, and other surface soil
2. Rinsing
3. Removing rust (omit only if parts are completely rust free)
4. Rinsing (omit only if parts are completely rust free)

COATING

1. Zinc phosphate coating (Class B Finish)
2. Rinsing
3. Final Acidulated rinsing

FINISHING

1. Drying
2. Oiling with a rust-preventive suitably reduced for application and containing corrosion inhibitors

Protection of Friction Surfaces

Design engineers have found that when two slick-finished metal surfaces are placed in close contact, the surfaces tend to hold one another tenaciously. This is evident from the widely known demonstration using two gage blocks. Inter-atomic forces are hard to overcome and are responsible for galling and scoring when even smooth surfaces are caused to slide over one another.

At one time, tin plating of friction surfaces was widely practiced to facilitate break-in or wearing-in of parts. However, because of the high cost and, even more important, the strategic na-

MILITARY SPECIFICATIONS COVERING PHOSPHATE COATINGS

This chart is intended to aid product engineers in the selection of phosphate finishes for military equipment. Phosphate finishes are effective, economical and easy to apply. Accordingly, they are required for an increasing majority of military products.

In the present system, specifications covering phosphate coatings are generally included with those for other classes of finishes. To make the information on phosphate coatings given in these specifications more easily obtainable, this chart lists the applicable specifications and outlines the requirements given in each on the following:

1. Type of Finish
2. Typical Metal Products Treated
3. Summary of Process
4. Pre-cleaning Data
5. Supplementary Finish

This is another in PRODUCT ENGINEERING'S series of charts on finishing processes. Charts on the following subjects have already appeared.

1. Electrolytic and Chemical Finishes — Product Engineering, Feb., 1951
2. Textured Organic Coatings — Product Engineering, April, 1951
3. Which Surface Hardening Process — Product Engineering, Aug., 1951

MILITARY SPECIFICATIONS COVER

Specification No.	Specification Title	Type of Finish	Metal Products Treated	Summary of Process
PROTECTING FERROUS METAL SURFACES FROM RUST				
U.S.A. No. 57-0-2C	Finishes, protective, for iron and steel parts.	Phosphate coatings finished with a rust-preventive suitably reduced for application and containing corrosion inhibitors. Described in this Specification as Type II, Class B.	Nuts, bolts, screws, hardware tools, guns, cartridge clips, and other non-moving parts.	CLASS B FINISH. The properly cleaned articles should be immersed for in a hot, balanced phosphate rust-proofing solution containing nitrate as for one hour, in a hot, dilute acid phosphate solution without an accele form crystalline phosphate coating is formed, after which the parts sho in clean water followed by a second rinse in a controlled dilute chromic a a suitable corrosion resistant finish should be applied. (Concentration suc phating solution should require not less than 30 ml of N/10 sodium hyd
U.S.A. No. 51-70-1A	Painting and finishing of fire control instruments; general specification for.	Similar to above, but described as "Finish 22.02, Class B Phosphate, steel."	Fire control instruments and accessories.	Chemical surface treatment in accordance with Type II of U.S. Army
JAN-L-548A	Link, metallic belt, 20 MM., M8.	Phosphate coating conforming with the requirements of U.S. Army Specification No. 57-0-2, Type II, Class B.	Metallic belt links.	CLASS B FINISH. The properly cleaned articles should be immersed fo a hot, balanced phosphate rust-proofing solution containing nitrate as for one hr in a hot, dilute acid phosphate solution without an accelerat crystalline phosphate coating is formed, after which the parts should clean water followed by a second rinse in a controlled dilute chromic a a suitable corrosion resistant finish should be applied. (Concentration su phating solution should require not less than 30 ml of N/10 sodium hyd
M-364	Navy aeronautical process specification for compound phosphate rust-proofing process.	Compound phosphate coating.	Metal aircraft parts after machining.	The parts are inserted in the bath and coating is continued until the evo practically ceases.
MIL-C-16232	Coatings — phosphate; oiled, slushed, or waxed (for ferrous metal surfaces) and phosphate treating compounds.	Phosphate Coatings on surfaces of non-moving parts or where bearing friction is not likely to be encountered. Described in this specification as Type II.	Nuts, bolts, screws, hardware, tools, guns, cartridge clips, and other non-moving parts.	After sufficient time of immersion in the phosphate treating bath the t oughly rinsed in a clean overflowing water bath for not less than 60 s through the water rinse shall be so regulated in conjunction with the r no time will the main body of the rinse become contaminated. Immed rinse the parts shall be treated in an acidified final rinse according manufacturer of the phosphate coating compounds.
PREPARATION OF STEEL AND IRON SURFACES FOR PAINTING				
JAN-C-490	Cleaning and preparation of ferrous metal surfaces for organic protective coatings.	A treatment which produces an adherent, crystalline phosphate deposit on a previously clean, ferrous, metal surface. Described in this specification as Grade I.	Projectiles, rockets, bombs, rifles, small arms, belt links, cartridge tanks, vehicular sheet metal, tank bolts and links, recoilless guns.	The properly cleaned articles should be subjected to a balanced phos nitrate as an accelerating agent (or other phosphate solution which is k alent results), until a uniform crystalline phosphate coating is obtaine be rinsed in clean water, followed by a second rinse in a dilute chromi
U.S.A. No. 57-0-2C	Finishes, protective, for iron and steel parts.	Similar to above, but described as "Type II, Class C, Phosphate coatings suitable for finishing with paint products."	Projectiles, rockets, bombs, rifles, small arms, belt links, cartridge tanks, vehicular sheet metal, tank bolts and links, recoilless guns.	The properly cleaned articles should be subjected to a balanced phos nitrate as an accelerating agent, until a uniform crystalline phosphate which the articles should be rinsed in clean water followed by a secon acid solution, then dried immediately and painted.
U.S.A. No. 51-70-1A	Painting and finishing of fire control instruments; general specification for.	Similar to above, but described as "Finish 22.02, Class C. Phosphate, steel."	Fire control instruments and accessories.	Chemical surface treatment in accordance with Type II of U.S. Army
U.S.A. No. 50-60-1	Containers, metal, for artillery and rocket ammunition.	Phosphate coating meeting the requirements of specification JAN-C-490. (Grade I Finish.)	All types and sizes of complete round containers and cartridge storage cases used for artillery ammunition, rockets and components.	Upon completion of the machining operations, the cartridge storage cas tainers shall be cleaned to free them of all grease, dirt, chips and other be given a phosphate coating preparatory to painting.
MIL-E-917 A (Ships)	Equipment, electric power, basic requirements for (naval shipboard use).	Phosphate coating meeting the requirements of specification JAN-C-490. (Grade I Finish.)	Electric (but not electronic or interior communication) equipment used for Naval shipboard applications.	A hot dip tank phosphate or chromate-phosphate treatment conformin 490, Grade I, followed by one coat of primer.
MIL-S-5002	Surface treatments (except priming and painting) for metal and metal parts in aircraft.	Phosphate coatings shall be applied in such a manner as to produce coatings in accordance with Specification JAN-C-490, Grade I.	Land planes (all aircraft operated entirely with wheel type landing gear) whether shore based or carrier based.	The properly cleaned articles should be subjected to a balanced phos nitrate as an accelerating agent (or other phosphate solution which is kn lent results), until a uniform crystalline phosphate coating is obtained. rinsed in clean water, followed by a second rinse in a dilute chromi

COVERING PHOSPHATE COATINGS

f Process	Pre-Cleaning Notes	Supplementary Finish
hould be immersed for not less than 30 minutes n containing nitrate as an accelerating agent, or tion without an accelerating agent, until a uni- er which the parts should be immediately rinsed rolled dilute chromic acid solution. After drying, ied. (Concentration such that 10 ml of the phos- ml of N/10 sodium hydroxide for neutralization.)	Parts to be processed should be free from all oil, grease, burrs, rust, and loose scale.	A thorough coating of rust-inhibiting oil or compound which after application is centrifuged or drained.
Type II of U.S. Army Specification No. 57-0-2.	Parts to be processed should be free from all oil, grease, burrs, rust, and loose scale.	Rust-preventive oil.
should be immersed for not less than 30 min in containing nitrate as an accelerating agent, or n without an accelerating agent, until a uniform which the parts should be immediately rinsed in rolled dilute chromic acid solution. After drying, lied. (Concentration such that 10 ml of the phos- ml of N/10 sodium hydroxide for neutralization.)	Parts to be processed should be free from all oil, grease, burrs, rust, and loose scale.	The phosphated links shall be coated with compound rust preventive grade 1, Ordnance Department, U.S. Army Tentative Specification AXS-1759. The residual coating of rust preventive compound shall not be in excess of 25 milligrams per link.
continued until the evolution of hydrogen bubbles	Iron and steel parts shall be cleaned and, if necessary, pickled in accordance with specification PT-4 or by an approved electrolytic descaling process. Sand blasting may be used where the size and tolerances of the parts will permit and where the carbon content is not over 0.6 percent. Heavy oxide scale shall be removed by pickling in a solution of sulphuric acid containing approximately one pound of acid per gallon. All parts shall be thoroughly rinsed in clean water after each cleaning and pickling operation. It may be necessary to scrub certain parts with sand or pumice to obtain thorough cleaning.	Paralketone, Type B of Navy Aeronautical Specification RM-61, or equivalent.
te treating bath the treated parts shall be thor- for not less than 60 seconds. The flow of water conjunction with the rate of production that at contaminated. Immediately following the water final rinse according to the instructions of the ds.	The base metal shall be subjected to such finishing and cleaning procedures as are necessary to insure phosphate coatings having the required appearance and quality. The preparation shall be controlled so as not to adversely affect the surface condition, form, or shape of the part as required by the applicable drawing.	Unless otherwise approved Type II phosphate coatings shall be impregnated with a solution of a rust preventive compound acceptable to the procuring agency.
ed to a balanced phosphate solution, containing ate solution which is known to accomplish equiv- ate coating is obtained. The article should then nse in a dilute chromic acid solution and dried.	Any common degreasing method can be used: alkali cleaning; phosphoric acid cleaning; emulsion-alkali cleaning; vapor-degreasing; solvent wiping; etc. Acid cleaning may need to follow other cleaning methods if rust or scale is present.	Organic coatings (paint, varnish, lacquer, enamel, etc.).
d to a balanced phosphate solution, containing crystalline phosphate coating is obtained after r followed by a second rinse in a dilute chromic d.	Parts to be processed should be free from all oil, grease, burrs, rust, and loose scale. Same methods as those mentioned for JAN-C-490.	Enamel, Olive Drab, Rust-Inhibiting (unless otherwise specified) conforming to the requirements of U.S.A. Specification No. 3-181.
Type II of U.S. Army Specification No. 57-0-2.	Parts to be processed should be free from all oil, grease, burrs, rust, and loose scale. Same methods as those mentioned for JAN-C-490.	Various finishes, depending on individual requirements.
cartridge storage cases or complete round con- dirt, chips and other foreign material and shall ing.	The preliminary cleaning to remove contamination may be any method which is adequate and which does not interfere with the phosphate coating process.	Both interior and exterior surfaces of the case or container body and cover assemblies as indicated on the drawings shall be coated with one coat of olive drab enamel, U.S.A. Specification No. 3-181.
treatment conforming to Specification JAN-C-	Remove all rust and other visible corrosion products. Remove all grease, oil, and dirt by solvent wiping, vapor-degreasing, or caustic washing and rinsing.	One coat of primer in accordance with any of the following specifications: JAN-P-72, JAN P-735, or HIL-P-6889 applied as a continuous film 0.0002 to 0.001 inch thick, followed by two coats of gray enamel, conforming to type II or III, Class 2 of Specification MIL-E-15090, applied as continuous films, each approximately 0.001 inch thick.
d to a balanced phosphate solution, containing te solution which is known to accomplish equiva- e coating is obtained. The article should then be se in a dilute chromic acid solution and dried.	Cleaning shall be accomplished with materials and processes which have no deleterious effect on the metal, and which produce surfaces satisfactory for the application of the surface treatment required. All parts after cleaning shall be free from rust, scale, paint, grease, oil, flux and other foreign matter.	Priming and painting information not included.

PROTECTING FRICTION SURFACES AND PROVIDING RUST RESISTANCE

MIL-C-16232, Type I	Coatings — phosphate; oiled, slushed or waxed (for ferrous metal surfaces) and phosphate treating compounds.	Coatings on bearing surfaces where a finish with a moderate degree of corrosion resistance is required to prevent wear and assist in "break-in" of bearing surfaces. Described in this specification as Type I.	Pistons, piston rings, cylinders, cylinder liners, gears, camshafts, crankshafts, and other friction surfaces.	After sufficient time of immersion in the phosphate treating bath the tre oughly rinsed in a clean overflowing water bath for not less than 60 se through the water rinse shall be so regulated in conjunction with the ra no time will the main body of the rinse become contaminated. Immedia rinse the parts shall be treated in an acidified final rinse according to manufacturer of the phosphate coating compounds.
U.S.A. No. 57-0-2C	Finishes, protective, for iron and steel parts.	Phosphate coatings finished with non-drying petroleum oils containing corrosion inhibitors, suitable for use on sliding and bearing surfaces and with the build-up limited to a maximum of 0.0003 inch per surface. Described in this specification as Type II, Class A.	Friction surfaces such as pistons, piston rings, gears, cylinder liners, camshafts, tappets, crankshafts, rocker arms. Also small arms, weapon components.	CLASS A FINISH. Immerse the properly cleaned parts for not less tha to 210 F), balanced manganese acid phosphate rust-proofing solution accelerating agent, until a uniform and finely crystalline coating is ob articles should be rinsed in clean hot water, followed by a second rins chromic acid solution. After drying, a suitable corrosion resistant finish coating should be used where a non-galling finish is desired.
U.S.A. No. 51-70-1A	Painting and finishing of fire control instruments; general specification for.	Similar to two preceding but described as "Finish 22.02, Class A, Phosphate, steel."	Fire control instruments and accessories.	Chemical surface treatment in accordance with Type II of U.S. Army S

PREPARATION OF ZINC AND CADMIUM SURFACES FOR PAINTING

QQ-P-416	Plating, cadmium (electro deposited).	Supplementary phosphate treatment, to form a good base for paint. Described in this specification as Type III.	Aircraft engine parts, springs.	Not described.
RR-C-82	Cans, corrugated, ash and garbage, tapered side, zinc-coated, with covers.	Zinc phosphate coating (U.S. Army requirement).	Cans of the fabricated corrugated type, with tapered sides, of the following rated capacities in United States liquid gallons: 5, 10, 16, 24, and 32 gallons.	The zinc coated can and cover shall be thoroughly cleaned to remove all g rial and subjected to a hot, balanced, zinc phosphate, rust proofing sa and nickel as accelerating agents, until a uniform crystalline coating is treatment, the can shall be rinsed in clean hot water and dried.
JAN-F-495	Finishes for equipment hardware.	Satisfactory, uniform phosphate coating.	Small hardware items such as buckles, clips and snaps, manufactured for attachment to equipment.	Standard phosphate coating process for zinc indicated but not described
U.S.N. Appendix 6	Instructions for painting, general specifications for building vessels of the United States Navy.	Zinc phosphate coating.	Naval vessels and component parts.	Approved cleaner consisting of phosphates, phosphoric acid and suita agents shall be applied to galvanized surface with a large brush, or sp surface shall be thoroughly rinsed with fresh water, preferably hot.

PREPARATION OF ALUMINUM SURFACES FOR PAINTING

MIL-C-5541	*Chemical films for aluminum and aluminum alloys.	Chemical films intended for use as a paint base and as a corrosion preventive film for aluminum and aluminum alloys.	Aircraft and aircraft parts (aluminum).	Chemical films shall be produced by suitable treatments controlled and c product. Usually the process consists of cleaning, rinsing, coating, and acidulated rinse.
MIL-S-5002	Surface treatments (except priming and painting) for metal and metal parts in aircraft.	Chemical film which meets requirements of Specification MIL-C-5541.	Metal surfaces of aircraft airframes and parts prior to application of primer and paint coatings, and also where primer and paint are not required — fuselages, wings, cowlings, struts, empennage, floats, etc.	Chemical films shall be produced by suitable treatments controlled and c product. Usually the process consists of cleaning, rinsing, coating, and acidulated rinse.
NAVORD O.S. 675	Specifications for the manufacture and inspection of cartridge, powder, and rocket tanks (aluminum).	Chemical film which meets requirements of Specification MIL-C-5541.	Cartridge tanks for fixed ammunition (cartridge cases with projectiles); cartridge tanks for cartridge cases of semi-fixed ammunition (without projectiles); powder tanks for powder in bags — interior surfaces not to be treated; rocket tanks for rocket ammunition.	Chemical films shall be produced by suitable treatments controlled and c product. Usually the process consists of cleaning, rinsing, coating, and acidulated rinse.
16E4 (Ships)	Electronic equipment, naval ship and shore; general specification.	Protective chemical finish.	Electronic equipment, including all components (major units) sets, and systems used in radio, radar, sonar, loran, IFF, radiac, infrared, etc., used for Naval ship or shore application.	Chemical films shall be produced by suitable treatments controlled and c product. Usually the process consists of cleaning, rinsing, coating, and acidulated rinse.

*Chemical films produced under Specification MIL-C-5541 may be used in lieu of anodic films (Specification AN- QQ-A-696) when authorized by the Procuring Service.

e treating bath the treated parts shall be thor- or not less than 60 seconds. The flow of water onjunction with the rate of production that at contaminated. Immediately following the water nal rinse according to the instructions of the s.	The base metal shall be subjected to such finishing and cleaning procedures as are necessary to insure phosphate coatings having the required appearance and quality. The preparation shall be controlled so as not to adversely affect the surface condition, form, or shape of the part as required by the applicable drawing.	Unless otherwise approved, Type I phosphate coatings shall be impregnated with oil conforming to MIL-L-3150.
parts for not less than 15 min. in a hot (205 ust-proofing solution containing nitrate as an ystalline coating is obtained; after which the owed by a second rinse in a controlled dilute rrosion resistant finish should be applied. This s desired.	Parts to be processed should be free from all oil, grease, burrs, rust, and loose scale.	A thorough coating of rust-inhibiting oil or compound which after each application is centrifuged or drained.
Type II of U.S. Army Specification No. 57-0-2.	Parts to be processed should be free from all oil, grease, burrs, rust, and loose scale.	Rust-preventive oil.
	Not described.	No special requirement. However, paint coatings applied to cadmium surfaces with the supplementary phosphate coatings shall show no blistering following subjection to specified water-resistance test.
cleaned to remove all grease, oil, or other mate- phate, rust proofing solution containing nitrate crystalline coating is obtained. Following this ater and dried.	See Summary of Process.	No paint finish specified.
ated but not described in this spec.	The hardware items shall be thoroughly cleaned with an approved type cleaner, as used in best commercial practice, and washed to remove all traces of grease, oil, dirt, scale, rust, and foreign products.	Type II finish, coating, baked, urea formaldehyde, suitable for application on zinc or zinc-coated ferrous metals. Type II finish is intended for use where protection from corrosion is of major importance. This finish should always be used on steel equipment hardware that is a part of web or canvas products.
phoric acid and suitable solvents and wetting n a large brush, or sprayed on. When dry, the er, preferably hot.	No special pre-cleaning specified.	Primer, formula 84 (zinc chromate), or undercoat, formula 14 (anticorrosive, shipbottom), as required, shall be applied when surface is dry. Handling of the surface after coating and before application of primer shall be avoided if practicable.
nents controlled and operated to give a uniform rinsing, coating, and rinsing, including a final	All grease, oil, oxide film, paint, welding flux or other injurious foreign matter shall be removed from the parts before application of the chemical film. Casting skin shall be removed, where required. After cleaning, the parts shall not be handled in any manner which will allow fingerprints, dirt, dust and other foreign substances to contaminate the surface to be treated.	See AN Aeronautical Specifications AN-L-29 (Lacquer; Cellulose Nitrate); and AN-P-656 (Primer; Zinc Chromate).
nents controlled and operated to give a uniform rinsing, coating, and rinsing, including a final	All parts after cleaning shall be free from rust, scale, paint, grease, oil, flux and other foreign matter. The use of uninhibited alkaline materials, such as sodium hydroxide solutions, and the use of abrasives which accelerate corrosion of aluminum alloys, such as iron oxide rouge and steel wool are prohibited.	Not specified.
nents controlled and operated to give a uniform rinsing, coating, and rinsing, including a final	All aluminum surfaces shall be thoroughly cleaned in accordance with Joint Army-Navy Specification JAN-P-116, Appendix I, Section 3g or Method C-10, except that the alkaline cleaning compound (degreaser) shall be in accordance with Specification AN-C-174.	After assembly, the tank and cover shall be painted, on all exterior surfaces, with one coat of enamel. Bureau of Ordnance Specification 52E13 (Ord) blue-grey, so that the dry film thickness is 1.0 to 1.5 mils. The contacting surfaces between moving parts shall not be painted.
nents controlled and operated to give a uniform rinsing, coating, and rinsing, including a final	Thorough cleaning specified.	Primer to be zinc chromate conforming to Specification JAN-P-735 or AN-P-656. Equipment to be painted but not exposed to the weather shall receive a minimum of two coats which may be two finish coats or one primer and one finish coat. Equipment to be painted and exposed to the weather shall receive a minimum of one primer coat and two finish coats.

ture of tin, manganese-iron phosphate finishes have replaced tin plating in many instances. Frequently, this substitution has resulted in improved performance. The manganese-iron phosphate film is superior to tin because of its ability to absorb and retain oil. Also, it is accompanied by an etch pattern in the basis metal which is ideal for bearing surfaces.

The function of the manganese-iron phosphate coating is actually twofold. It imparts wear-resistance and anti-galling characteristics to reciprocating surfaces of machine elements. In addition, it provides excellent corrosion resistance when given either a chromic, phosphoric or phosphoric-chromic acidulated rinse and then sealed with a rust-preventive oil, compound or wax.

The properties of the manganese-iron phosphate coating that enable it to protect the underlying metal effectively are both chemical and mechanical. First, the chemical coating bath removes minute surface irregularities from ferrous metal surfaces and produces a coating of non-metallic, water-insoluble crystals. The latter hold oil as untreated metal cannot do. By preventing metal-to-metal contact, the coating prevents damage to parts from scuffing, scoring, galling, welding, and tearing. The coating deforms under pressure, thus reducing maximum stresses.

The mild abrasive properties of the crystalline layer assist in lapping or wearing in the parts which are in rubbing contact. This effect is helped by the absorption of a lubricating oil by the manganese-iron phosphate crystals. Such lubrication can be maintained under high pressure and high velocities. Finally, the etching action of the coating solution produces a porous surface under the coating. This improves the wearing qualities and provides minute oil reservoirs which remain even after all traces of the original coating have disappeared. The improved lubrication inhibits corrosion pitting of the surface and insures the presence of an oil film between parts that are put into motion after an idle period.

Manganese-iron phosphate coatings, containing non-drying petroleum oils with corrosion inhibitors and intended for sliding, rubbing, or bearing surfaces, meet the requirements for Type II, Class A of U.S.A. Specification 57-O-2C and other equivalent specifications. These coatings are used where a non-galling finish is desired. According to specification requirements, these finishes must withstand one hour of salt spray exposure when unoiled, and 24 hr salt spray exposure when treated with a suitable oil.

To obtain a Class A Finish, the properly cleaned (rust-free and scale-free) parts are immersed for not less than 15 min in a hot balanced phosphate solution containing nitrate as a accelerating agent. When a uniform crystalline phosphate coating is formed the parts are immediately rinsed in clean water, followed by a second rinse in a controlled dilute chromic acid solution. After drying, a suitable corrosion-resistant oil is applied.

Class "A" Finish or equivalent is now specified for small arms, machine gun parts, automotive and aircraft engine components, such as pistons, piston rings, cylinders, cylinder liners, crankshafts, camshafts, gears, tappets, valves, spiders, splines and other rubbing parts, tank treads, and many other components. Depending on the size of the parts, Class A Finishing can be carried out by dipping the steel or iron parts in the cleaning, rinsing and coating baths contained in tanks, or by treating such parts as bolts, nuts, screws and castings in tumbling barrels.

A relatively new use for phosphate coatings is as a lubricant-retaining film for the deep-drawing and cold extrusion of steel. This is of especial importance in the fields of steel cartridge case and projectile manufacture where such a lubrication system provides many advantages.

Certain characteristics of the phosphate coating facilitate the flow of cold steel. The non-metallic phosphate crystals are physically and chemically adapted to acquire a strongly adsorbed lubricant. The combination of adherent phosphate coating and adsorbed lubricating film possesses a low coefficient of friction while maintaining its integrity under extremely high deforming pressures.

The coating chemical is a modification of the conventional zinc phosphate type. On pickled surfaces it forms a tightly-bound, adherent, zinc-iron phosphate coating which aids the cold mechanical deformation of steel. This is made possible by the plastic-crystalline structure of the integral coating and its lubricant adsorptive properties.

The protective coating chemical is applied in an immersion or spray process. When used in conjunction with a suitable lubricant, the coating reduces friction under conditions of low, medium, or high deforming forces encountered in such operations as cold extrusion of steel; cold shaping; deep drawing (tubs, cartridge cases, shells, etc.); stamping; and the drawing of wire and tubing.

In the chart immediately following this article the requirements of the various military specifications relating to phosphate coatings are abstracted and tabulated. Object of the tabulation is to provide a convenient summary of the various coatings of most current interest.

Infantrymen loading 75 mm recoilless rifle. Finish on gun is Type II, Class A, covered by U. S. Army Specification 57-0-2C. This is a manganese-iron rust-proof coating plus a rust preventive oil. Projectiles are treated with zinc phosphate pre-paint solution (Grade I of JAN-C-490).
Signal Corps Photo

Using the Patent Office Files As a Design Source

The solutions to more than 2,500,000 design and development problems are now available in the patent files, and these files are easy to use once you know the system that is used in classifying and indexing material.

CHARLES E. BALLEISEN
Supervisor, Mechanical Laboratory
Southwest Research Institute

THE PRIMARY REASONS why greater use has not been made of the Patent Office files are: (1) it is difficult to know what patents have been issued in any specific field; (2) attempts to gather this information usually result in long and troublesome searches; (3) the precise, legal terminology used in patents makes it difficult to understand their contents.

The first two obstacles, knowing what patents have been issued and locating those patents pertaining to a given subject, can be overcome only by a complete understanding of the system used by the Patent Office in filing and indexing its material. For this purpose, the publications issued by this office, listed in part in Table I, can be used for reference.

Most engineers are familiar with the weekly Patent Gazette, which lists all new patents in numerical order. Although the Gazette is basically a legal document and is not ideally adapted to solving specific design problems, it does contain an abstract, consisting of one representative claim and one drawing from each patent, and three indexes; one of patentees' names, one by type of invention, and one in which the patents are grouped according to the Patent Office classification system. By proper use of these indexes it is possible, for anyone, lawyer or designer, to become acquainted with new developments in any field as these developments become patented.

Most searches for data will involve patents that have been issued in the past as well as the current items contained in the Gazette. In these cases, abstracts are usually not available and the classification system is the only practical reference tool. Under this classification system, all patents are grouped in 346 classes, each of which is subdivided into numerous subclasses. A partial list of the classes is given in Table II covering those items that are of primary interest to design engineers.

Table I — PARTIAL LIST OF ITEMS SOLD BY THE U. S. PATENT OFFICE

The Patent Gazette (weekly; the Index may be purchased separately at a cost of $4.80)	$38.75 per yr
Manual of Classification (approximate cost)	4.00
Classification of Patents (weekly)	1.00 per yr
Classification Bulletins (published as needed, containing definitions, searching suggestions; varying prices)	0.10-1.20 each
Copies of individual U.S. patents	0.25 each

The system of classes has been developed gradually over the last one hundred years. Changes and additions have been made as inventions and discoveries have opened new fields. Anyone who anticipates much patent searching should obtain from the Commissioner of Patents a copy of the Manual of Classification as this is the key and index to the entire classification system.

This manual contains numerical and alphabetic indexes and also shows some general groupings of the classes to illustrate the content of each class and the relationship between classes. Most of this book is devoted to listings of the subclasses within each class. These subclasses are given in a single numerical sequence, but they are arranged to indicate, by successive indenting, finer and finer degrees of classifications.

A section from the listings of Class 73—Measuring and Testing is shown in Fig 1. Subclass 138 should be read as: Dynamometers, Torque During Transmission, Total Registering, as in the third indentation, subsidiary to subclass 133 (Dynamometers) and subclass 136 (Torque During Transmission). Thus the classification system begins with a broad, basic classification, and proceeds to more specific differentiation as sufficient patents accumulate to warrant establishing separate subclasses. In using these indexes, the searcher should proceed to the farthest applicable indentation. If the data are not found there, he can work backward to broader and more comprehensive subclasses.

The listing of the subclasses in the Manual of Classification is necessarily limited to a bare title. To clarify these titles, the Patent Office has prepared definitions of the subclasses, which

Table II — PARTIAL LIST OF THE CLASSES OF THE U.S. PATENT SYSTEM

18. Plastics
22. Metal Founding
29. Metal Working
33. Geometrical Instruments
50. Fluid-Pressure Regulators
60. Power Plants
61. Hydraulic and Earth Engineering
62. Refrigeration
64. Machine Elements, Shafting and Flexible Shaft Couplings
73. Measuring and Testing
74. Machine Elements and Mechanisms
75. Metallurgy
78. Metal Forging and Welding
80. Metal Rolling
106. Compositions, Coating or Plastic
121. Motors, Expansible-Chamber Type
123. Internal-Combustion Engines
124. Mechanical Guns and Projectors
136. Batteries
138. Pipes and Tubular Conduits
148. Metal Treatment
151. Nut and Bolt Locks
153. Metal Bending
161. Time Controlling Mechanisms
170. Motors, Fluid Current
172. Electricity, Motive Power
173. Electricity, Connectors
174. Electricity, Conductors and Insulators
175. Electricity, General Applications
180. Motor Vehicles
184. Lubrication
188. Brakes
192. Clutches and Power-Stop Controls
193. Conveyors, Chutes, Skids, Guides, and Ways
198. Conveyors, Power Driven
200. Electricity, Circuit Makers and Breakers
201. Resistances and Rheostats
207. Plastic Metal Working
219. Electric Heating
230. Gas Pumps and Fans
237. Heating Systems
244. Aeronautics
249. Automatic Weighers
251. Valves
253. Motors, Fluid
254. Pushing and Pulling Implements
257. Heat Exchange
264. Speed-Responsive Devices
266. Metallurgical Apparatus
267. Spring Devices
277. Multiple Valves
280. Land Vehicles
284. Valved Pipe Joints or Couplings
285. Pipe Joints or Couplings
286. Packed Shaft or Rod Joints
287. Rod Joints or Couplings
288. Joint Packings
292. Closure Fasteners
297. Thermostats and Humidostats
302. Conveyors, Fluid Current
303. Fluid-Pressure Brake and Analogous Systems
308. Machine Elements, Bearings and Guides
309. Machine Elements, Cylinders and Pistons
318. Electricity, Motive Power Systems
346. Recorders

CLASS 73 MEASURING AND TESTING

Subclass

133 Dynamometers
134. Torque by Absorption
135 Friction Drag Type
136 Torque During Transmission
137 Recording
138 Total Registering
139 Torque Measuring Wrenches
140 Shaft or Bearing Thrust Measuring

Fig. 1—Partial list of subclasses used in classifying patents that are contained in the general category of measuring and testing devices.

133. Subject matter under the class definition for measuring torque, moments, work or power, i.e., measuring of force exerted or power exerted as by a machine doing work.

SEARCH THIS CLASS, SUBCLASS--
382, for gravitational determination.

SEARCH CLASS--
265, Weighing Scales for those devices that measure the effect of the pull of gravity on bodies.

134. Subject matter under Subclass 133 for measuring torque, work, or power of a prime mover or a rotating body wherein the energy of the prime mover or body is absorbed in the apparatus used.

SEARCH THIS CLASS, SUBCLASS--
116, for dynamometer devices used merely for loading in motor testing.

SEARCH CLASS--
188, Brakes, Subclass 90+, for rotary internal fluid resistance brakes per se and Subclass 104 for rotary magnetic brakes per se useful with dynamometers.

136. Subject matter under Subclass 133 for measuring torque, work, or power of a prime mover or rotating body wherein the torque, work, or power is measured during transmission.

SEARCH CLASS--
171, Electricity, Generation, Subclass 123+, for the structure of

138. Subject matter under Subclass 136 wherein the total force measured is registered or counted.

139. Subject matter under Subclass 133 comprising a tool in the form of a wrench similar torque applying tool with means

Fig. 2—Partial list of the definitions that have been prepared by the Patent Office to define the titles of the subclasses shown in Fig. 1.

describe the basis for determining each subclass and also suggest other subclasses where related material may be classified. Examples of these definitions are included as Fig 2. They pertain to some of the classes shown in the previous figure.

After having located the proper subclass, it is then relatively easy to get the number of the desired type of patent if one has been granted. This may be accomplished in one of two ways. First, a numerical list of the patents filed in that subclass can be purchased from the Patent Office. Second, the searcher can turn to the last page of each Patent Gazette and consult the Classification of Patents, wherein the patents issued that week are listed according to their classification. The author uses both these methods; the first to start a file, where the early art is desired, and the latter to keep it current. Separate classification sheets can be purchased for a fraction of the cost of the complete journal and these can be filed so that the recent issuances in any particuar class and subclass can be checked without fumbling through all the listings.

After locating the numbers of the patents classed in the field of interest, it is usually necessary to obtain and examine a copy of each patent. This can be obtained from the Patent Office for twenty-five cents, or it can be examined in the search room of the Patent Office in Washington or in any of the several public libraries that maintain patent files as official depositories.

As mentioned previously, even after locating the patent, many engineers have experienced difficulty in understanding its content. However, it must be remembered that each patent is a 17-year contract of monopoly between the United States Government and an inventor. As such a legal document, it must be drawn up in accordance with stringent rules. Its terminology must be precise when the matters legally covered by the patent are being defined. But this occurs only in the claims section of the written specification, and the remainder of the specification can usually be understood without difficulty. The entire written specification consists of three parts and is supported by drawings and illustrations, as necessary. The first part describes the object to be attained by the invention. The second part describes its structure and operation, and the third part is the claims section.

Unless he is interested in what is legally novel, the engineer can disregard the claims, since the drawings and description usually contain more material than is covered in the claims. Many aspects of the problem in which he is interested may not be patentable, and, further, as a patent application is processed, it may be divided, limited, or otherwise rejected in part before some of the claims are finally allowed to issue. In these cases, it is customary to allow the original drawings and description to stand as far as possible, both to avoid the cost of redrawing and to retain the broad coverage in the public records. Thus, a glance at the drawings of a newly-issued patent often gives the impression that the material is not unique, as the new invention may occupy only a small portion of the drawing.

Many industries have found it advisable to maintain classified files of the subclasses in which they are likely to be interested. Usually, this is an inexpensive way to keep up with the art and to avoid duplication of research effort. One of the ways in which such files are used at Southwest Research Institute is to maintain lists of patents issued in the field of measuring and testing (Class 73). These numbers are recorded as the patents are issued, and each abstract is scanned in the Gazette to determine the potential uniqueness and the applicability of the method. Those which appear to be of maximum value are purchased and studied in detail. They are filed then according to subclasses.

When a problem involving a difficult measurement requirement arises, is is easy to consult the file of patents. Failing a solution here, a 3 x 5 card can be consulted for other recent issues, and in the case of a problem which does not yield to these two attacks, a more general search according to the methods outlined in this article is then undertaken.

Impregnation Cuts Casting Porosity Rejects

POROSITY REJECTS in castings designed to be pressure tight can be materially reduced by impregnating the castings with thermosetting copolymers. In addition, treatment permits the design of light-weight thin structural walls to carry loads under pressure without leakage. Originally a salvage process, impregnation is now being used as a preventive treatment to avoil expensive rejects.

Causes of porosity in metal alloy castings may be generalized as:

1. Poor casting design.
2. Difference in solid solubility of the dissolved constituents at different temperatures.
3. Disruption along grain boundaries of the alloy constituents caused by tension stresses set up during cooling.
4. Improper foundry practice and techniques.

Impregnation is basically a method to seal porosity in castings. The sealant must penetrate through the casting wall in the micropores and no build-up of residue can be tolerated on machined surfaces, threaded areas, in ducts, or ports.

A typical sealant contains 100 per cent solids; is a thermosetting copolymer capable of withstanding extreme pressures and temperatures; and does not react with industrial liquids and gases. Its application is quick, economical, and permanent, and it is applied to both ferrous and nonferrous metals.

Large quantities of castings can be processed simultaneously by the use of batch methods. Parts are loaded into a dry autoclave from which air is evacuated for a given period of time. After the sealant is introduced under vacuum until all castings are completely immersed, the autoclave atmosphere is neutralized and then air pressure of at least 100 psi is built up and maintained for at least thirty minutes. Finally, the excess sealant is withdrawn, the parts drained and removed, rinsed in solvents, dried and cured at 300 F for ten minutes.

The amount and duration of pressure, as well as curing time, varies with the type of porosity, wall thickness, and condition of alloy casting being treated.

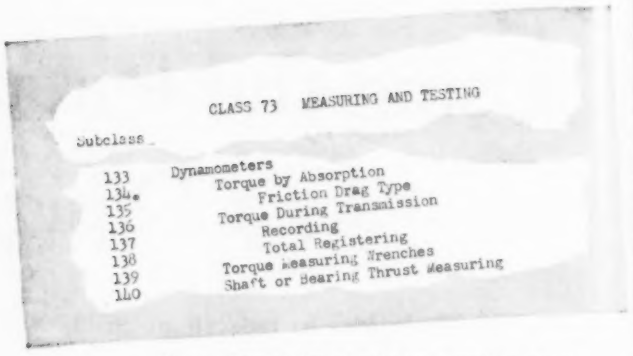
During impregnation, the viscosity of the sealant, as well as polymerization time must be controlled to assure uniform results.

Batch immersion methods and sealant described above have also been employed in a new technique for bonding of similar and dissimilar materials where lateral or internal pressures are required. Because the bonding agent is anhydrous and an excellent insulator, it will prevent electrolysis from taking place at the contact surfaces of dissimilar metals.

The parts to be bonded are assembled manually or hydraulically, depending upon the tolerances involved and put through the impregnation cycle and cured.

Table II — PARTIAL LIST OF THE CLASSES OF THE U.S. PATENT SYSTEM

18. Plastics
22. Metal Founding
29. Metal Working
33. Geometrical Instruments
50. Fluid-Pressure Regulators
60. Power Plants
61. Hydraulic and Earth Engineering
62. Refrigeration
64. Machine Elements, Shafting and Flexible Shaft Couplings
73. Measuring and Testing
74. Machine Elements and Mechanisms
75. Metallurgy
78. Metal Forging and Welding
80. Metal Rolling
106. Compositions, Coating or Plastic
121. Motors, Expansible-Chamber Type
123. Internal-Combustion Engines
124. Mechanical Guns and Projectors
136. Batteries
138. Pipes and Tubular Conduits
148. Metal Treatment
151. Nut and Bolt Locks
153. Metal Bending
161. Time Controlling Mechanisms
170. Motors, Fluid Current
172. Electricity, Motive Power
173. Electricity, Connectors
174. Electricity, Conductors and Insulators
175. Electricity, General Applications
180. Motor Vehicles
184. Lubrication
188. Brakes
192. Clutches and Power-Stop Controls
193. Conveyors, Chutes, Skids, Guides, and Ways
198. Conveyors, Power Driven
200. Electricity, Circuit Makers and Breakers
201. Resistances and Rheostats
207. Plastic Metal Working
219. Electric Heating
230. Gas Pumps and Fans
237. Heating Systems
244. Aeronautics
249. Automatic Weighers
251. Valves
253. Motors, Fluid
254. Pushing and Pulling Implements
257. Heat Exchange
264. Speed-Responsive Devices
266. Metallurgical Apparatus
267. Spring Devices
277. Multiple Valves
280. Land Vehicles
284. Valved Pipe Joints or Couplings
285. Pipe Joints or Couplings
286. Packed Shaft or Rod Joints
287. Rod Joints or Couplings
288. Joint Packings
292. Closure Fasteners
297. Thermostats and Humidostats
302. Conveyors, Fluid Current
303. Fluid-Pressure Brake and Analogous Systems
308. Machine Elements, Bearings and Guides
309. Machine Elements, Cylinders and Pistons
318. Electricity, Motive Power Systems
346. Recorders

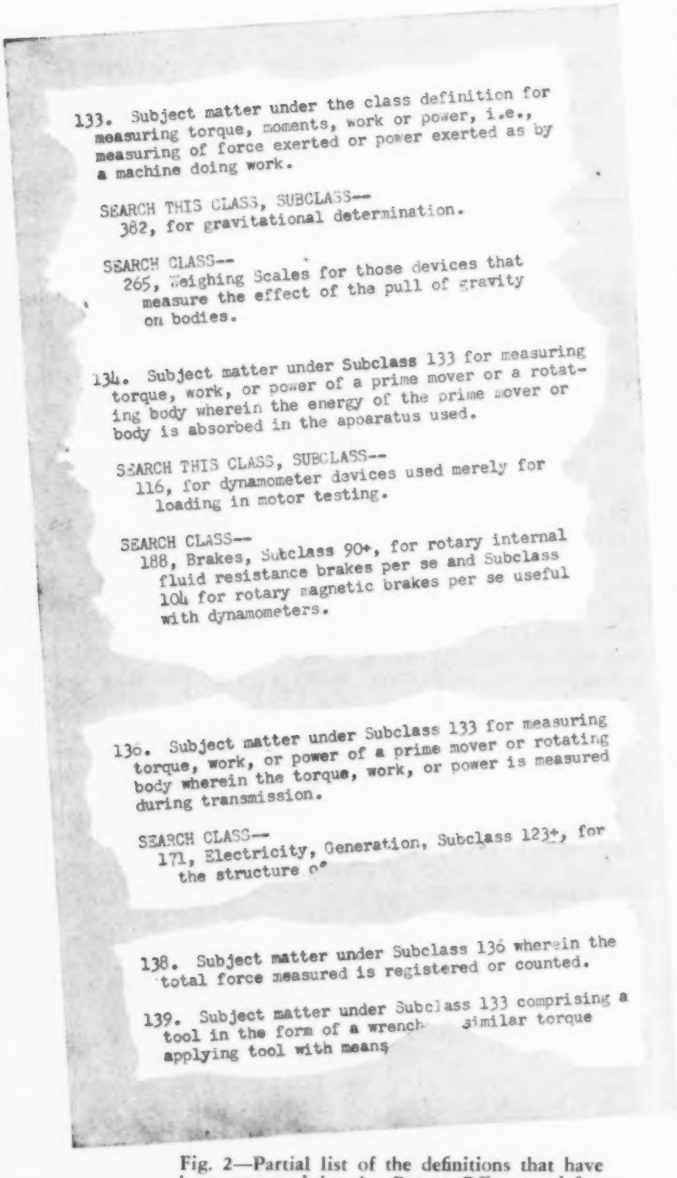


CLASS 73 MEASURING AND TESTING

Subclass

133 Dynamometers
134. Torque by Absorption
Friction Drag Type
135 Torque During Transmission
136 Recording
137 Total Registering
138 Torque Measuring Wrenches
139 Shaft or Bearing Thrust Measuring
140

Fig. 1—Partial list of subclasses used in classifying patents that are contained in the general category of measuring and testing devices.



133. Subject matter under the class definition for measuring torque, moments, work or power, i.e., measuring of force exerted or power exerted as by a machine doing work.

SEARCH THIS CLASS, SUBCLASS--
382, for gravitational determination.

SEARCH CLASS--
265, Weighing Scales for those devices that measure the effect of the pull of gravity on bodies.

134. Subject matter under Subclass 133 for measuring torque, work, or power of a prime mover or a rotating body wherein the energy of the prime mover or body is absorbed in the apparatus used.

SEARCH THIS CLASS, SUBCLASS--
116, for dynamometer devices used merely for loading in motor testing.

SEARCH CLASS--
188, Brakes, Subclass 90+, for rotary internal fluid resistance brakes per se and Subclass 104 for rotary magnetic brakes per se useful with dynamometers.

136. Subject matter under Subclass 133 for measuring torque, work, or power of a prime mover or rotating body wherein the torque, work, or power is measured during transmission.

SEARCH CLASS--
171, Electricity, Generation, Subclass 123+, for the structure of

138. Subject matter under Subclass 136 wherein the total force measured is registered or counted.

139. Subject matter under Subclass 133 comprising a tool in the form of a wrench or similar torque applying tool with means

Fig. 2—Partial list of the definitions that have been prepared by the Patent Office to define the titles of the subclasses shown in Fig. 1.

describe the basis for determining each subclass and also suggest other subclasses where related material may be classified. Examples of these definitions are included as Fig 2. They pertain to some of the classes shown in the previous figure.

After having located the proper subclass, it is then relatively easy to get the number of the desired type of patent if one has been granted. This may be accomplished in one of two ways. First, a numerical list of the patents filed in that subclass can be purchased from the Patent Office. Second, the searcher can turn to the last page of each Patent Gazette and consult the Classification of Patents, wherein the patents issued that week are listed according to their classification. The author uses both these methods; the first to start a file, where the early art is desired, and the latter to keep it current. Separate classification sheets can be purchased for a fraction of the cost of the complete journal and these can be filed so that the recent issuances in any particuar class and subclass can be checked without fumbling through all the listings.

After locating the numbers of the patents classed in the field of interest, it is usually necessary to obtain and examine a copy of each patent. This can be obtained from the Patent Office for twenty-five cents, or it can be examined in the search room of the Patent Office in Washington or in any of the several public libraries that maintain patent files as official depositories.

As mentioned previously, even after locating the patent, many engineers have experienced difficulty in understanding its content. However, it must be remembered that each patent is a 17-year contract of monopoly between the United States Government and an inventor. As such a legal document, it must be drawn up in accordance with stringent rules. Its terminology must be precise when the matters legally covered by the patent are being defined. But this occurs only in the claims section of the written specification, and the remainder of the specification can usually be understood without difficulty. The entire written specification consists of three parts and is supported by drawings and illustrations, as necessary. The first part describes the object to be attained by the invention. The second part describes its structure and operation, and the third part is the claims section.

Unless he is interested in what is legally novel, the engineer can disregard the claims, since the drawings and description usually contain more material than is covered in the claims. Many aspects of the problem in which he is interested may not be patentable, and, further, as a patent application is processed, it may be divided, limited, or otherwise rejected in part before some of the claims are finally allowed to issue. In these cases, it is customary to allow the original drawings and description to stand as far as possible, both to avoid the cost of redrawing and to retain the broad coverage in the public records. Thus, a glance at the drawings of a newly-issued patent often gives the impression that the material is not unique, as the new invention may occupy only a small portion of the drawing.

Many industries have found it advisable to maintain classified files of the subclasses in which they are likely to be interested. Usually, this is an inexpensive way to keep up with the art and to avoid duplication of research effort. One of the ways in which such files are used at Southwest Research Institute is to maintain lists of patents issued in the field of measuring and testing (Class 73). These numbers are recorded as the patents are issued, and each abstract is scanned in the Gazette to determine the potential uniqueness and the applicability of the method. Those which appear to be of maximum value are purchased and studied in detail. They are filed then according to subclasses.

When a problem involving a difficult measurement requirement arises, is is easy to consult the file of patents. Failing a solution here, a 3 x 5 card can be consulted for other recent issues, and in the case of a problem which does not yield to these two attacks, a more general search according to the methods outlined in this article is then undertaken.

Impregnation Cuts Casting Porosity Rejects

POROSITY REJECTS in castings designed to be pressure tight can be materially reduced by impregnating the castings with thermosetting copolymers. In addition, treatment permits the design of light-weight thin structural walls to carry loads under pressure without leakage. Originally a salvage process, impregnation is now being used as a preventive treatment to avoil expensive rejects.

Causes of porosity in metal alloy castings may be generalized as:

1. Poor casting design.
2. Difference in solid solubility of the dissolved constituents at different temperatures.
3. Disruption along grain boundaries of the alloy constituents caused by tension stresses set up during cooling.
4. Improper foundry practice and techniques.

Impregnation is basically a method to seal porosity in castings. The sealant must penetrate through the casting wall in the micropores and no build-up of residue can be tolerated on machined surfaces, threaded areas, in ducts, or ports.

A typical sealant contains 100 per cent solids; is a thermosetting copolymer capable of withstanding extreme pressures and temperatures; and does not react with industrial liquids and gases. Its application is quick, economical, and permanent, and it is applied to both ferrous and nonferrous metals.

Large quantities of castings can be processed simultaneously by the use of batch methods. Parts are loaded into a dry autoclave from which air is evacuated for a given period of time. After the sealant is introduced under vacuum until all castings are completely immersed, the autoclave atmosphere is neutralized and then air pressure of at least 100 psi is built up and maintained for at least thirty minutes. Finally, the excess sealant is withdrawn, the parts drained and removed, rinsed in solvents, dried and cured at 300 F for ten minutes.

The amount and duration of pressure, as well as curing time, varies with the type of porosity, wall thickness, and condition of alloy casting being treated.

During impregnation, the viscosity of the sealant, as well as polymerization time must be controlled to assure uniform results.

Batch immersion methods and sealant described above have also been employed in a new technique for bonding of similar and dissimilar materials where lateral or internal pressures are required. Because the bonding agent is anhydrous and an excellent insulator, it will prevent electrolysis from taking place at the contact surfaces of dissimilar metals.

The parts to be bonded are assembled manually or hydraulically, depending upon the tolerances involved and put through the impregnation cycle and cured.

TECHNICAL NEWS

New Magnetic Ship Models Laboratory Opened by Navy

THE WORLD'S LARGEST SHIP MODELS LABORATORY devoted to developing improved protective devices for ships against magnetically exploded mines and torpedoes has recently been put in operation at the U. S. Naval Ordnance Laboratory, White Oak, Maryland. Almost entirely automatic in operation, the equipment more than doubles former facilities.

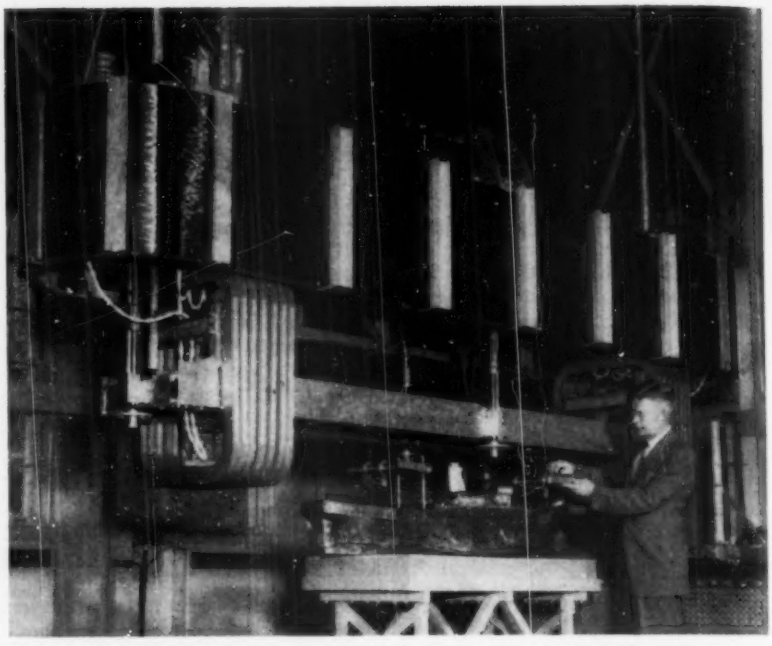
Heart of the lab, according to C. Leland Parsons, head of the laboratory's operations, is a powerful magnetic field, uniform throughout a volume in space 5 x 5 x 10 feet. Magnitude ranges from zero milligauss to 1,000 milligauss, about twice the earth's field. A less uniform but more intense demagnetizing field of 50 gauss can also be produced.

The field is developed by three mutually perpendicular cable loops, held accurately in place by wooden cable carriers mounted on the inner surfaces of the coil room. The coil is wound of special 37 conductor cables distributed to produce the desired uniform field.

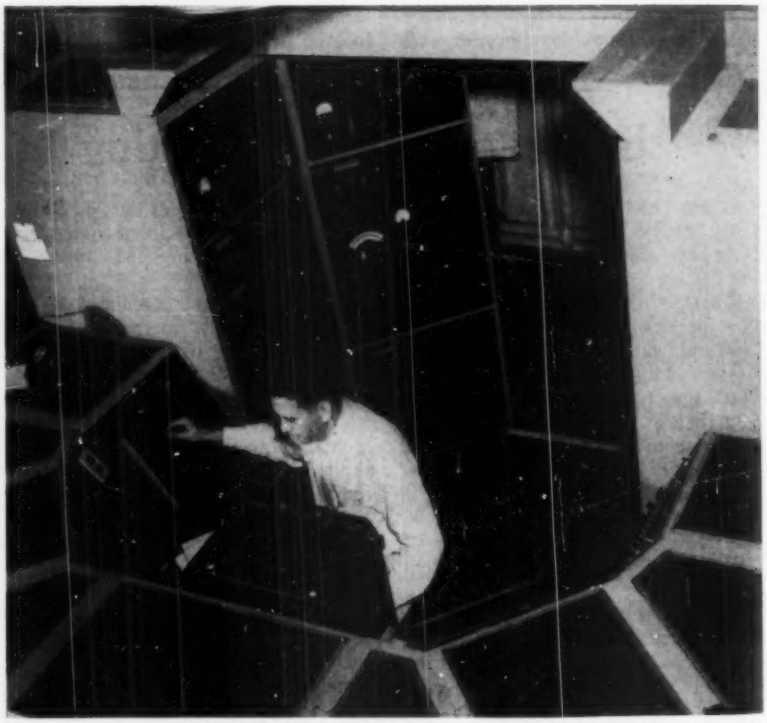
Two additional heavy current a-c solenoids, the "z-shaker" and the "x-shaker", are used to control magnetic fields at the center of the measurement area. These shakers demagnetize or normalize the ship model before measurement. The axis of the z-shaker field is vertical, while that of the x-shaker lies parallel to the north-south directions.

An ingenious device called the model hoist and support frame places the ship model in the field at a location that is accurately known and readily reproducible. Constructed of aluminum V-channels, it is kept in the proper horizontal position by vertical guide rods at each end that telescope into aluminum tubes. The frame is precisely located vertically by adjustable automatic latches at each side. A ½ hp d-c motor with a speed reducer raises and lowers the frame.

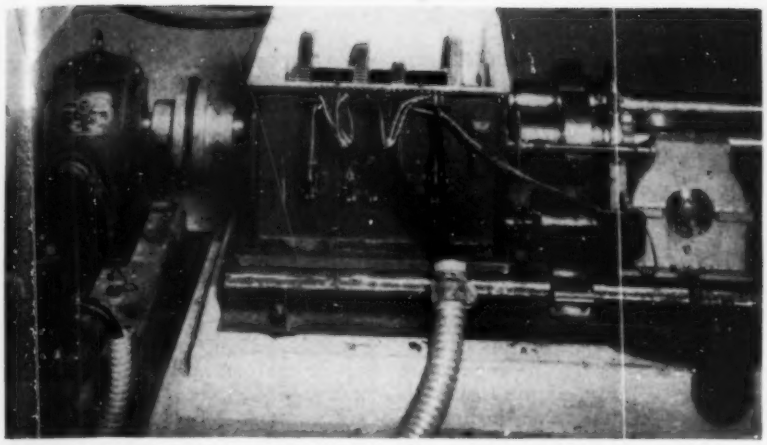
Adjustable cross bars span the support frame and the ship model is suspended from these "yoke bars." One end of each bar rests in a V-block to assure east-west alignment, while the other end rests in a gear tooth fixture for north-south location.



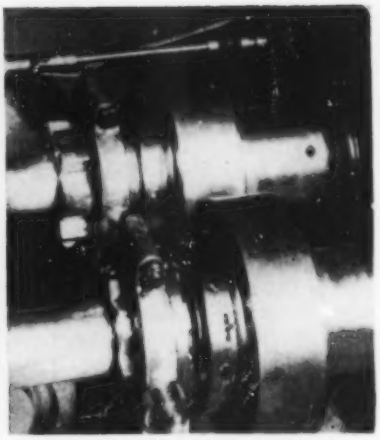
NAVY SHIP MODELS in a magnetic sea develop protection methods against mines and torpedoes. Housed in a building in an isolated area and designed specifically for magnetic measurements, the laboratory is constructed completely of non-ferrous material.



MASTER CONTROL CONSOLE that is ten feet in diameter brings the 357 dials, switches, and meters required for proper operation within the reach of one person. This feature has speeded up the collection of data and has reduced the personnel requirement for this operation from three men to a single operator.



POWER SYSTEM for driving automatic translator consists of ½ hp motor, 90-1 gear reducer and gear ratio box. Drive spiders and twin disk clutches which transmit power to the two 23-foot long vertical drive shafts are also visible.



CLUTCH SYNCHRONIZER opens and closes twin disk clutches with cam operated levers as the gear cluster moves.

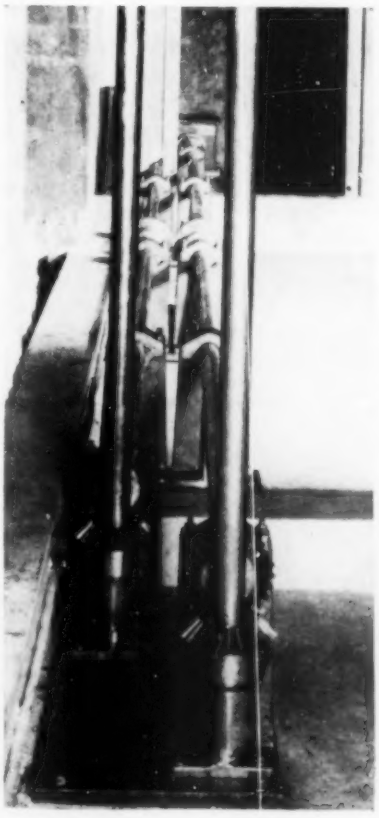
FIELD DETECTION EQUIPMENT is moved in three directions at adjustable constant velocity and located with an accuracy of 0.010 in. by the automatic translator. The longitudinal carriage moves on rails in the north-south direction; the transverse carriage moves in the east-west direction on rails mounted on top of the longitudinal carriage; the vertical tower mounted on the transverse carriage moves in the vertical direction and carries on its top surface the magnetic field detector.

Source of power is a ½ hp d-c motor coupled to a 90-1 gear reducer. In turn, the gear reducer is coupled to a ratio gear box which determines the ratio of rpm and direction of rotation of the longitudinal and transverse drive shafts. The gear box drives two 23 ft long drive shafts through drive spiders and twin disk clutches.

A clutch synchronizer opens and closes the twin clutches through cam operated levers as the gear cluster is moved from position to position by the rotation of a lead screw. In all, there are five different positions of the cluster.

Rotation of the drive shaft is transmitted to the magnet room through miter gears, vertical shafts, and a second set of miter gears. The latter are geared to two drive sprockets which pull roller chains to give translatory motion to the carriages.

The delivery of power to the longitudinal carriage is simple but the delivery of power to the transverse carriage is complicated. The transverse chain passes under an idler sprocket mounted at the bottom of the longitudinal carriage, over a power sprocket and down under a second idler sprocket, and then out to the return sprocket at the far end of the rail system. Rotation of the power sprocket is transmitted, through a short shaft and miter gears, to a drive sprocket at one end of the longitudinal carriage. As it pulls a third loop of roller chain, the drive sprocket causes the transverse carriage to move in an east or west direction.



MITER GEARS and vertical shafts transmit power from the lower level to the magnet room that is upstairs.

Since the motions of the two carriages are interlocked, it is necessary to predetermine their relative direction and velocity to obtain the desired resultant motion or path of the detector in the horizontal plane of 0, 30, 45, 60 and 90 deg from magnetic north. The ratio gear box performs this function.

One of the carriages is locked or pinned in place for the 0 and 90 degree paths. This is done with pairs of remotely controlled "pin-in" mechanisms, which drive tapered pins into precision cut slots along the edges of all rails. The midget motors used for this device are known to be magnetically invisible to the detector at a distance of 20 inches and have been so located.

Business Paper Editors Select Steel Production As Outstanding Development

DEVELOPMENTS IN THE PRODUCTION and use of steel represent the most significant engineering advance of the past century according to the majority opinion of editors of 32 leading trade journals and business publications. The editors were polled by Dr. John R. Dunning, dean of engineering, at Columbia University.

Reasons for steel's selection included such achievements as the Bessemer converter, the regenerative principle of steel-making, the construction of high-speed continuous mills for rolling steel strip and sheet, the skeleton frame-curtain wall concept of building, the development of many alloys, and the many improvements in the quality of steel alloys.

New Flat Glass Absorbs Heat Reduces Glare

A GREENISH TINT GLASS that absorbs the sun's heat, reduces eyestrain, and prevents the fading and bleaching of fabrics has been developed by the Pittsburgh Plate Glass Company. Called Solex, the new glass can be bent, laminated or tempered for use in practically every known type of flat glass application.

By absorbing the red glare-producing portion of the light spectrum along with infrared and ultraviolet radiation, and transmitting adequate soft daylight for clear visibility, the glass affords a host of applications ranging from protection of delicate electronic instruments to use in airport control towers.

Solex absorbs about 80 percent of incident infrared radiation; transmitting between 72 an 74 percent of visible light. It excludes 65 percent of direct solar radiation by absorbing 60 percent and reflecting five percent.

ASEE Wants Teaching Aids

THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION has issued a call to industry, professional societies, research organizations, and engineering colleges for teaching aids which may be reviewed in its forthcoming Catalog of Teaching Aids.

Purpose of the catalog will be to assist instructor in choosing aids that most suit his needs, and to assure him that these have been passed upon by competent individuals. Particularly desired are those that provide students with an understanding of fundamentals rather specific manual operations.

The first edition will be confined to civil, electrical and mechanical engineering, mathematics, and engineering mechanics. Information on such devices should be submitted to Prof. C. W. Muhlenbruck, Chairman ASEE Committee on Teaching Aids, Northwestern Tech. Inst., Evanston, Ill., and should include a description or photograph and operating instructions.

Remote Control Microscope

A SPECIAL "REMOTE CONTROL" MICROSCOPE, developed for the Knolls Atomic Power Laboratory of G.E., now permits atomic scientists and researchers to work in safety while studying the structure of radioactive materials. First of its kind, the instrument is expected to make possible investigations that have never before been accomplished on the effects of radiation damage to materials.

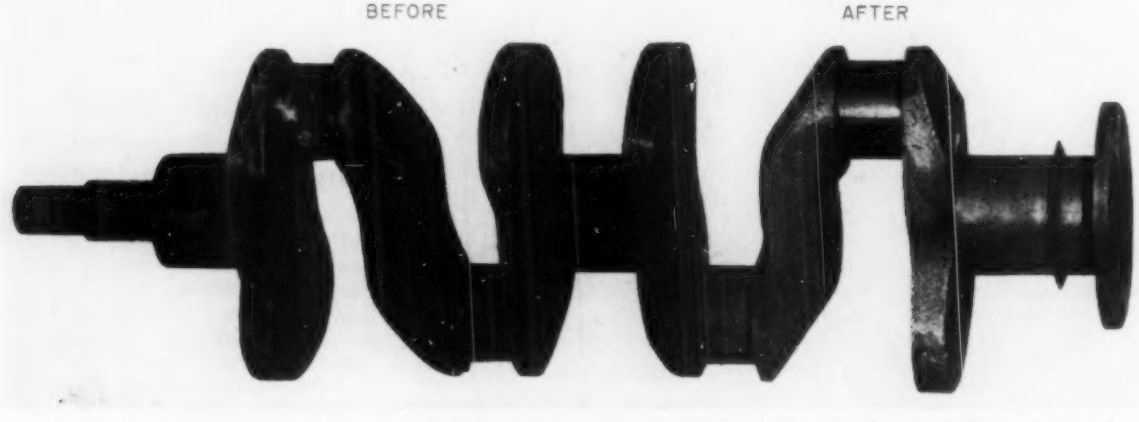
The microscope is combined with camera, periscopes and an illuminating system, in such an arrangement that light for illumination of the specimen can get in and out, but nuclear radiations from speciments are blocked.

This light goes into the chamber through a lens system placed in a tubular hole through the wall, is reflected from the specimen, and comes out again through another series of lenses, to form the magnified image.

Both lens systems are offset by means of mirrors, which change the light path from horizontal to vertical, and then back to horizontal again. Radiations from inside the test cell are not reflected, and cannot get around the off-set. If the tube were straight, however, they might be able to emerge through the opening for the lenses.

Remotely controlled "mechanical hands," can be used to place the specimens in position, and to remove them after examination.

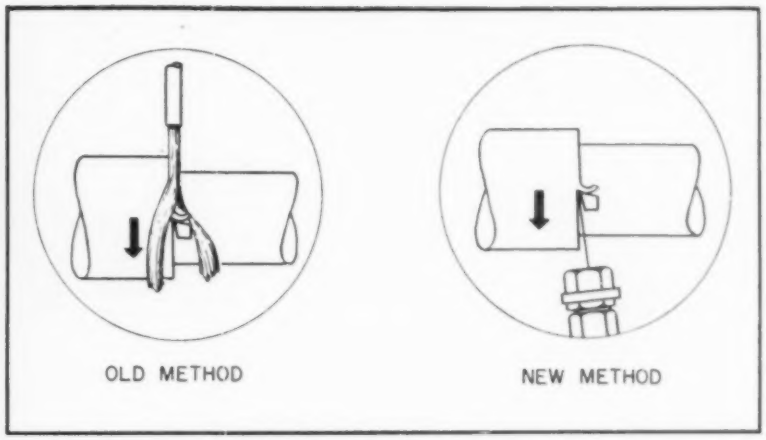
At the lowest power, the instrument shows the specimen in its actual size, without any magnification, whereas 1,000 diameters magnification may be obtained with the highest power. These different powers are achieved by the use of several objective lenses for the microscope, which are mounted on a revolving turret and can be swung into place as desired. The objectives are so adjusted that it is not necessary to refocus when changing from one magnification to another.



STEEL CRANKSHAFT illustrates the effects of derusting with new electrolytic process developed by the Enthone Corporation (link on right has been derusted). Using an alkaline bath instead of the conventional acid pickling bath, the new process will clean steel, cast iron, malleable iron and other iron alloys without subsequent rusting and attacking of the base metal or corrosion of the bath container. High carbon steels subject to discoloration even in inhibited acids can be derusted without any trace of tarnish or attack. It can be done in a steel tank at room temperature.

Corroded piece is made the cathode in a solution of derusting compound for a period ranging from a few seconds to several minutes depending on the condition of the surface and current density. Speed of the operation —much faster than acid pickling— depends on the current density which ranges from five to several hundred amps per square foot depending on the particular application. Zinc can be incorporated in the bath so that cleaning, derusting, and zinc plating can be done in one production operation.

HI-JET can be applied to most turning operations and single point tool machines including milling machines, gear cutters, and some broachers.



COMPARISON OF the overhead flood (left) and high-jet (right) techniques shows how the high pressure jet is forced past the cutting edge of the tool to lubricate and cool the critical surface, while in the older method, the chip obscures the cutting edge and prevents lubricant from reaching it.

High Pressure Jet Boosts Tool Life And Cutting Speeds

TOOL LIFE INCREASED 600 to 1,200 percent or cutting speeds increased up to 300 percent are two of the advantages claimed for the new "Hi-Jet" machining process developed by the Gulf Oil Corporation.

Using a specially developed oil which not only cools but also lubricates the tool during machining, the method extends the use of many materials previously limited in design applications because of machining difficulties. Even such problem metals as titanium and Inconel have been turned with relative ease using the new technique.

Instead of the conventional overhead flood of coolant on the tool, the Hi-Jet apparatus directs high pressure (400 psi) streams of oil upward to the underside of the cutting edge so that oil actually passes the cutting edge and is caught between the chip and the tool. The high temperature of the cutting edge vaporizes this oil and removes heat from the most critical area, the cutting edge. The vaporized oil is then condensed on the cooler chip or tool shank, while a downward shower bath of oil cools the tool shank and prevents the formation of smoke.

The unit which can be adopted to standard lathes, milling machines, gear cutting equipment, broaches, and most other types of single-point or form tools consists of: an electric motor, pump, pressure regulating valve, jet nozzle (sharp edge orifice), nozzle holder and special, low pressure shower heads. These shower heads are used only as smoke quenchers.

Most difficult part of applying this technique is the aligning of the jet nozzle. Advantages of the new technique are lost unless the jet is carefully aimed so that it is always in contact with the cutting edge of the tool in such a way as to avoid chip interference.

Additional advantages claimed for the process include: the elimination of tool build up and radius wear with their resultant damage on the work; extension of the use of high speed steel cutting tools with a conserving of tungsten carbide tools; decreased tendency towards work hardening of machined parts; improvement of surface finishing reducing the need for some finishing operations. In some cases the finishing operations can be completely eliminated.

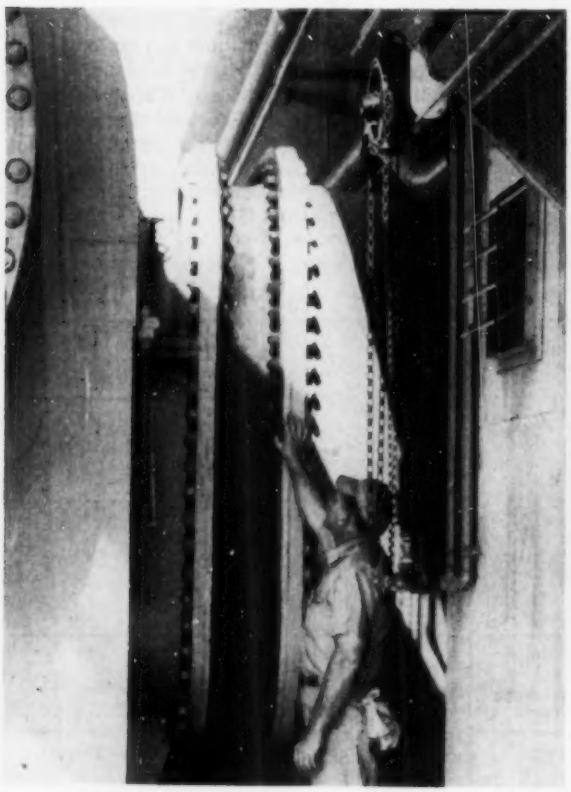
Gulf has licensed Thompson Products, Inc. of Cleveland to manufacture the units and it is expected that units will be available in July of this year. Additional information can be obtained from D. P. Clark, General Sales Manager, Gulf Oil Company, Gulf Building, Pittsburgh, Penna.

Steel	Cutting Conditions	Tool Material	Tool Life Time Min	
			Overhead Flood	Hi-Jet
SAE 3150	110 sfm 0.011 in. feed 0.150 in. depth of cut	18-4-1 High-Speed Steel	10.02 12.60	177
AISI 3140	140 sfm 0.011 in. feed 0.150 in. depth of cut	18-4-1 High-Speed Steel	9.3 24.0 16.0 23.0	339.5
SAE 1020	212 sfm 0.033 in. feed 0.125 in. depth of cut	18-4-1 High-Speed Steel	1.27	19.5
AISI 416 Stainless	160 sfm 0.011 in. feed 0.150 in. depth of cut	18-4-1 High-Speed Steel	9.4	163.4

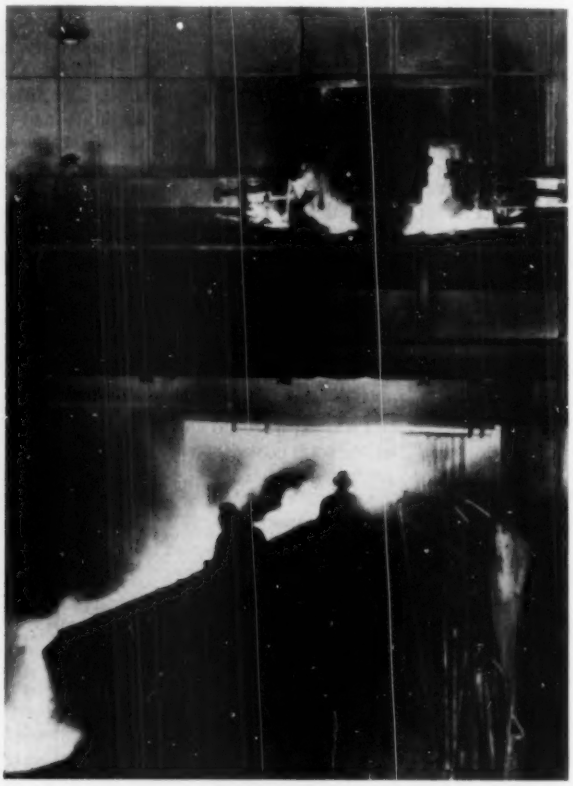
TABLE REPORTS results of tests contrasting old and new methods of metal cutting. Multiple entries for overhead flood method indicate tests with different types of cutting oil. Only Gulf Hi-Jet oil was used with new method.

THE NEWS IN PICTURES

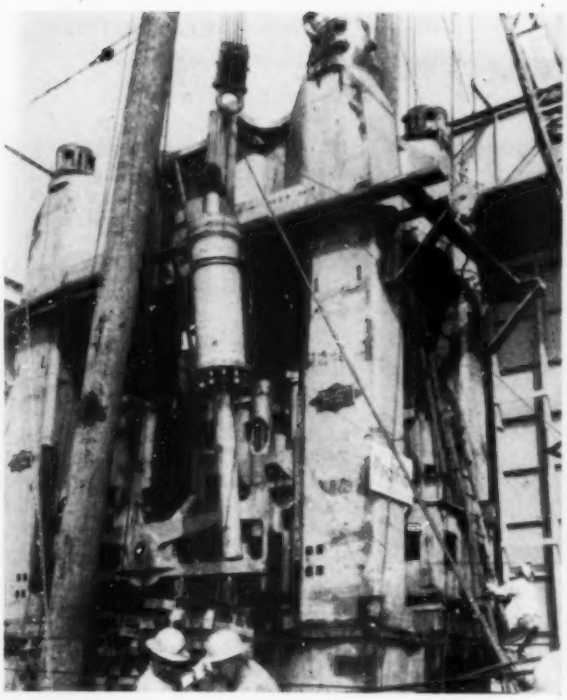
FIRST JET-PROPELLED FLYING LABORATORY utilizes a North American B-45 to flight test General Electric turbojet engines. The test engine is carried in a specially designed nacelle under the bomb bay while the plane itself is equipped with four jet engines for propulsion. Special instruments installed in the plane record the test engine's performance.



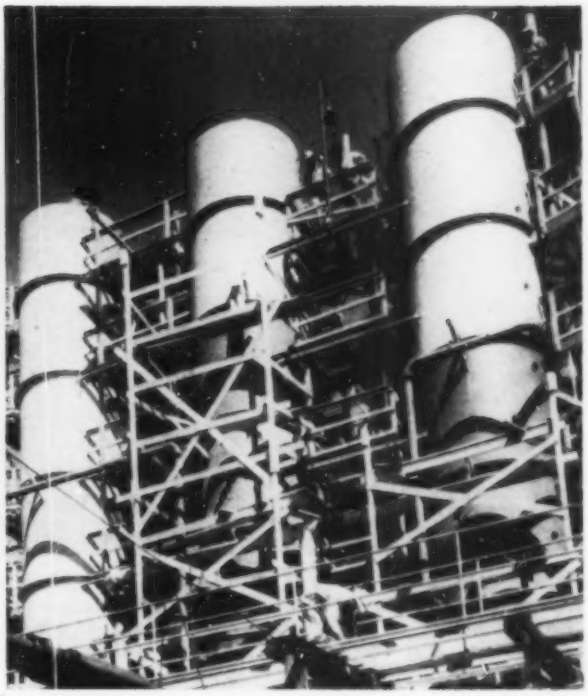
THIS RUBBER AND FIBER EXPANSION JOINT built by the U. S. Rubber Company is eight feet high, 21 feet wide, and one foot face to face. Recently installed in a power plant, it compensates for the expansion and contraction between turbine and condenser, isolates vibration, and supplies a tight durable seal.



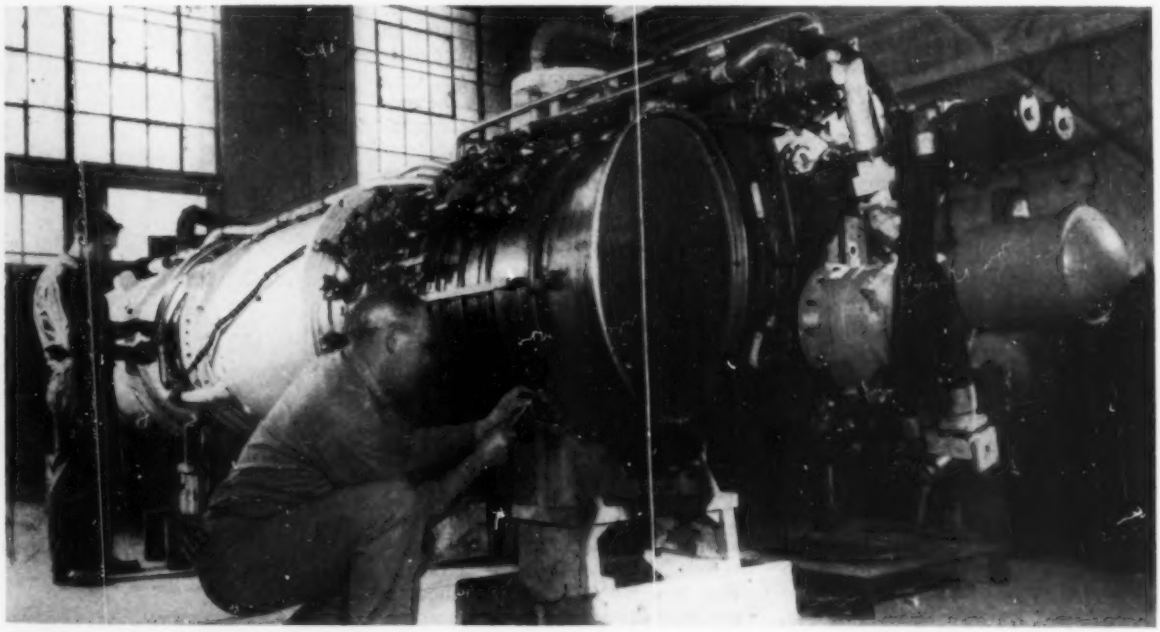
FERRO-ALLOY STEEL PRODUCTION will get a substantial boost when the Electro Metallurgical Company's $100,000,000 plant is completed at Marietta, Ohio. Pictured here is one of the four electrical furnaces already in operation. Completed plant will have 24 electrical furnaces of this type.



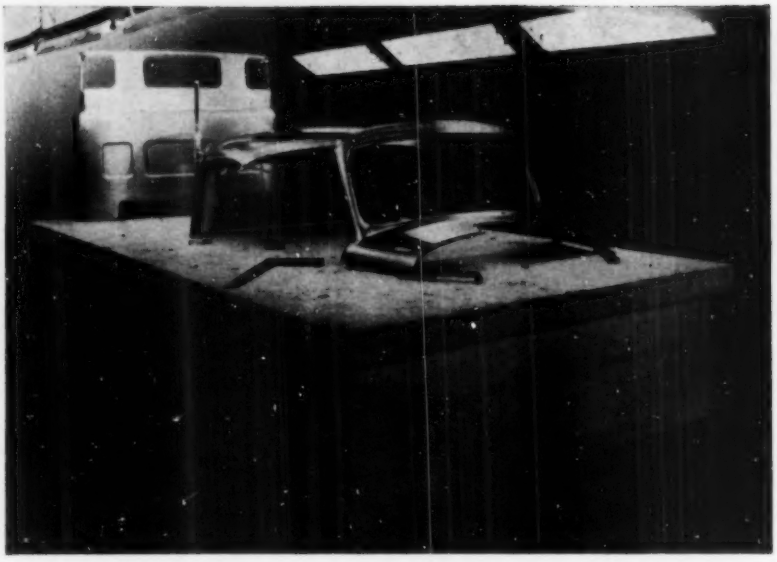
WORLD'S LARGEST HYDRAULIC PRESS in the aircraft industry is being installed at the Burbank, California plant of the Lockheed Aircraft Corporation. Designed and built by Birdsboro Steel Foundry and Machine Company, the press is four stories high and weighs more than 1,100 tons. Walls and a roof will be erected later, after the installation of the press itself is finally completed.



GOVERNMENT SYNTHETIC RUBBER PLANT in Port Neches, Texas has been reactivated by the U. S. Rubber Company to add 72,000 tons of material annually to U. S. supplies. Mocernization, which included the addition of eight new stainless steel drier flights for carrying wet crude rubber through drying ovens, boosted plant's production to a value that is 12,000 tons over the World War II output.



WOOD, GLUE, AND SCREWS are the principal materials in this mock-up of the Westinghouse J-40 jet aircraft engine at the company's Aviation Gas Turbine Division. Precise replica of the stainless steel and aluminum engine being produced for the U. S. Navy enables airplane designers to make the necessary allowances for size of accessories and other problems involving the engine's configuration. The wood construction allows the model shop to keep the engine up to date as changes evolve from the engineering department. The mock-up can also be used to help locate electrical, hydraulic and fuel lines properly.



ULTRA-PRECISE INSPECTION OF dimensions, tolerances and other engineering details of metal stampings are performed at Toledo's City Auto Stamping Company on a single block of granite having no seams, flaws or soft spots. The stone, reported to be the largest block of granite ever quarried measures 192 x 96 x 32 in. and weighs 50,000 lb in finished form. It is installed on a 32 in. concrete foundation, resting on three rubber cushions placed between the foundation and the stone itself.

Heat Resistant Adhesives Replace Rivets

HEAT RESISTANT ADHESIVES, widely used in brakes and automatic transmissions, are doing the job of rivets and weathering some of the roughest tests automobile parts can undergo. Such adhesives also are being used successfully to join both metal and non-metal parts that require good strength and performance at high temperatures.

While the adhesives have given very good service in their present applications, as indicated by the performance of millions of brake shoes and transmission parts in the automotive industry, further development is underway with so-called phenolic-elastomer adhesives.

In laboratory tests on a brake dynamometer with 500 pounds per square inch air line pressure for the braking action, the adhesive bond between the brake lining and brake shoe withstood temperatures, caused by friction, as high as 1,021 degrees Fahrenheit without failure of the bond. Even when the brake lining was worn through to the bonding surface, the bonding surface showed no signs of failure.

The heat resistant, high strength, thermosetting adhesives are suitable for a wide range of applications, since they can be used to join a variety of materials. Facing material on (automatic transmission) clutch disks varies from the cork and paper type to a metallic type facing. The adhesives also have shown good adhesion to many metals.

Two of the main adhesives used in the automotive industry are thermosetting, which remains relatively unchanged after it is cured, and thermoplastic, which is rigid at low temperatures and soft and pliable at high temperature. Both types, generally require heat to form a bond. The main difference between them is their behavior at high temperatures.

Atomic Pile Equipment Generates Electricity

FIRST ELECTRIC POWER produced from heat energy released in the operation of a nuclear pile provided light and power for electric accessories at the AEC's Idaho Falls Testing Station.

Thermal energy was removed from the reactor by liquid metal at a temperature high enough to generate steam to drive a turbine. While the experiments were designed to secure experimental information on the handling of molten metals, the 100 kw generator introduced possibilities for future developments in power generating equipment.

Driven Filler Rod Propels New Welding Torch

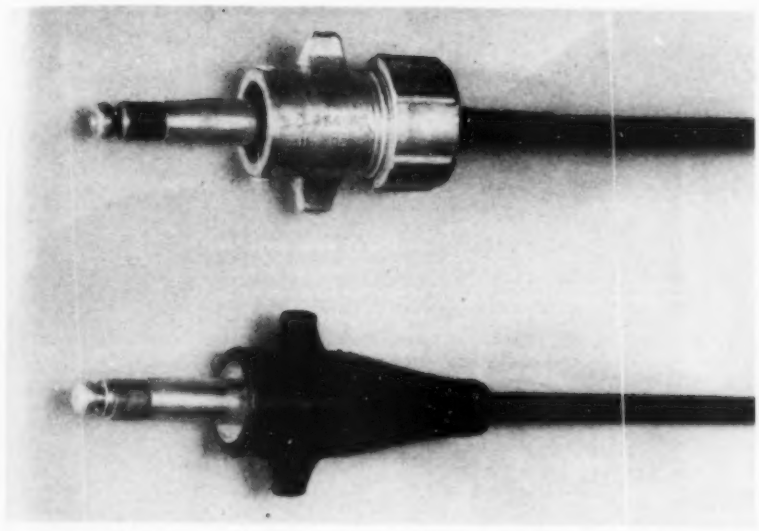
PROPELLED BY DRIVEN FILLER ROD, a new semi-automatic welding torch developed by Linde Air Products Company facilitates uniform welding speed and arc heat distribution.

Welding is accomplished by an arc between a tungsten electrode and the work piece as the filler rod is drawn from a reel by electrically powered drive rolls and fed through a flexible conduit into the welding puddle. During the operation, the welding operator has to apply only light pressure to hold the guide nozzle against the work. The driven rod causes the torch to move in any direction that the welding operator steers it, and at the same time maintains constant arc length.

The rate of rod feed can be set at any desired speed up to 100 in. per minute and constant speed is assured by an electronic governor. Welding speed nearly equals the rod feed rate as the welding rod is melted under the arc at the rate of approximately one inch of weld per inch of torch travel.

Linde reports high quality welds have been made with this new type of torch in carbon steels and stainless steels from 0.020 inches to 0.125 inches in thickness.

DRIVEN BY FEEDER ROD, semi-automatic welding torch produces high quality welds in carbon and stainless steels.



MOLDED PLASTIC JACK-PLUG CONNECTOR (lower) replaces Navy Bureau of Ordnance aluminum unit (upper) in aircraft rocket igniters.

Molded Jack Plug Design Saves Time and Metal

BY REPLACING a thirteen piece aluminum jack-plug connector with a five piece injection molded part, the Hatfield Wire and Cable Company speeded up production of the units for the armed services and made substantial savings of the hard-to-get metal.

The Hatfield unit consists of one basic sub-assembly soldered to the firing cable and a polystyrene shell integrally molded in place. The assembly consists of a brass contact shaft, a one piece outer contact and shell stamped and drawn (including two extrusions which serve as bayonets for mating with the female conductor), and two phenolic insulators.

Big time saver in the new design is the elimination of the hand assembly of the separate parts that composed the old jack plug. Production was increased by injection molding since only limitation is the capacity of the molding machines and the number of shifts worked. The molding around the contact assembly provides a uniform construction that is moisture-proof, corrosion-resistant and tamper-proof.

Solder joints replace friction fits to assure more positive electrical contact in the new unit. And the molding compound itself acts as an insulator to prevent short circuits while separating and locking the wire leads and contacts into position.

The unit was tested and accepted by Bureau of Ordnance, Department of the Navy and the Air Force.

NBS Reports on Copper Creep Investigations

EXTENDING THEIR STUDIES of high-purity copper creep to include cold-drawn copper, the National Bureau of Standards has announced results of their latest investigations. Employing copper cold-drawn to a 40 percent reduction in area, specimens were tested for their creep characteristics at 110, 250, and 300 F with constant loads in tension.

Results indicate that the shape of the extension-time curves was similar to that previously observed for annealed copper, high purity aluminum and ingot iron. Deformation in the second stage of creep was discontinuous, the degree of discontinuity being affected by test temperature and stress. No simple relation was found between the ductility of the cold-drawn copper and the time required to attain either the third stage of creep or complete fracture.

The cold-drawn copper appeared markedly superior to annealed copper in resistance to creep and to fracture. This superiority in strength, however, was accompanied by a considerable loss in elongation at fracture for equivalent second-stage creep rates and temperatures. The reduction of area at fracture was about the same for both forms of copper.

A NEW DEVICE, the Sinusoidal Scanning Trace Converter, produced at the Naval Ordnance Laboratory, White Oak, Maryland, converts recorded data back to the operating current which originally drew the curve. The device is quite simple in principal, very accurate, and can be adapted for a very high speed response. The Sinusoidal Scanning Trace Converter holds considerable promise since through its use field data can be recorded and later reconverted to current for use in laboratory tests in mines and other underwater ordnance. Data recorded as a curve by an Esterline-Angus Recorder is transformed into current by the converter so that the exact effects of the original field conditions can be reproduced for testing new mechanisms under Laboratory conditions.

•

AN F-86D SABRE ALL-WEATHER FLIGHT SIMULATER built for the Air Force is the first to simulate two planes in flight—the one being flown and an approaching enemy plane. Thus Sabre jet pilots training in the new all-weather interceptor can learn how to handle their high speed planes without leaving the ground, and will be able to bag an enemy plane approaching at the speed of sound, with the advantage of getting another chance if they miss. The electro-mechanical trainer contains over 100,000 parts, including 1152 electronic tubes and 60 miles of wiring, and will be delivered to the Air Force with the formation of each new F-86D squadron.

•

GRAINS OF RICE forced at high speed under air pressure into the combustion chambers of an automobile engine have been found to be effective in removing objectionable deposits without tearing down the engine. Koroseal hose, made to withstand the air pressure, is attached to a special nozzle that is inserted into the spark plug ports. Through this hose, the rice flow can be seen.

•

RESISTANCE WELDER MANUFACTURER'S ASSOCIATION is offering $2,250 in cash prizes for outstanding papers on research, design, and application of resistance welding equipment. Judges for the contest which places no restrictions on the scope of subject matter will be appointed by the American Welding Society. Additional information is available from the Resistance Welder Manufacturer's Association at 1900 Arch Street, Philadelphia 3, Pennsylvania.

Heating elements embedded in Silastic are used to prevent icing of air intake doors on jet engines.
In diesel-electric locomotives, Silastic gaskets for cylinder liners, water ports and oil pans, eliminate major overhauls previously caused by premature failure of organic rubber seals.
In spite of hot oil and long exposure to temperatures ranging from below zero to 400-450° F., Silastic spark plug boots exclude moisture; make automobile engines easy to start on wet mornings.

Silastic* works where ordinary rubber fails

At temperatures from −100° to over 500° F.,
in contact with hot oil at 350-400° F.,
in spite of weather, corona, shock and vibration,
you can count on Silastic to maintain a tight seal
or to confine electricity at high or low voltages.
That's proved by the fact that Silastic is used
to insulate traction motors, Navy control cable and
ignition cable for aircraft and ordnance vehicles.
It's used to seal heating and deicing systems,
bomb bay doors, limit control switches
and rocker box covers on aircraft;
sole plates in domestic steam irons;
cylinder liners and water ports in
diesel-electric locomotive engines.

For more information, mail this coupon today.

DOW CORNING CORPORATION
Dept. No. R—14, Midland, Michigan
Please send me
☐ Silastic Facts No. 10 on properties and performance
☐ List of Silastic Fabricators
Name_____ Title_____
Company_____
Address_____
City_____ Zone___ State_____

DOW CORNING CORPORATION
DOW CORNING SILICONES
MIDLAND, MICH.

ATLANTA
CHICAGO
CLEVELAND
DALLAS
NEW YORK
LOS ANGELES
WASHINGTON, D. C.

In Canada: Fiberglas Canada Ltd., Toronto
In England: Midland Silicones Ltd., London

*T.M. Reg. U.S. Pat. Off.

Design Charts for Large Compression Springs

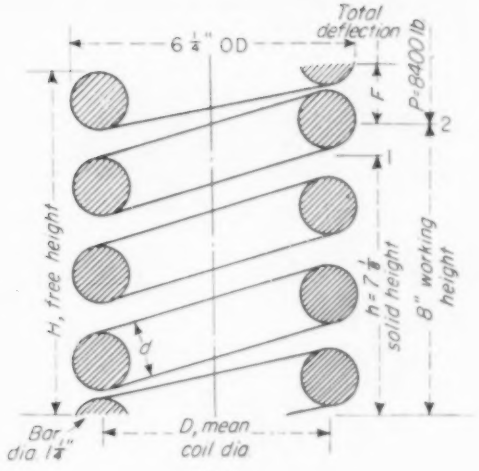


Fig. 1

APPLICATIONS SUBJECTED TO HIGH SHOCK OR IMPACT LOADS often require large springs. One example is that of railroad equipment where hot wound helical springs are used. These charts are for calculating such springs made of round bars ranging in diameter from $\frac{1}{2}$ to $2\frac{1}{4}$ in. This method of design differs in that the solid height is considered as an independent variable.

Fig. 2 lists δ, (the deflection per inch of effective solid height) as a function of the outside diameter and the bar diameter. These curves are based on Eq(1) with a reference stress S of 100,000 psi and do not include the "Wahl" factor.

$$\delta = \frac{\pi S D^2}{G d^2} \tag{1}$$

where: D is the mean coil diameter, in.; d the wire or rod diameter in.; and G is the torsional modulus of 10.5×10^6 psi.

As a rule, the solid stress should not exceed 100,000 psi for carbon steel springs subjected to occasional solid closures. For good service, the solid stress should be as far below this value as practicable. It is recommended that the working stress for dynamically loaded springs should not exceed 60 per cent of the solid stress. The graph of Figs. 3 and 4 is based on the relation:

$$P = \frac{\pi S d^3}{8 D} \tag{2}$$

and arranged to determine the load P (lb) for springs with different outside diameters and bar sizes at $S = 100{,}000$ psi.

Example: A compression spring shown in Fig. 1 is to be designed with an outside diameter of $6\frac{1}{4}$ in. and with a bar size of $1\frac{1}{4}$ in. dia. The solid height is to be $7\frac{1}{8}$ in. and the corresponding stress should be 90,000 psi. The force acting on this spring is 8,400 lb at 8.0 in.

(a) The free height can be calculated from Eq(3). However a value of δ must first be found. From Fig. 2, $\delta = 0.48$ at 100,000 psi. At 90,000 psi, it is:

$$\delta_1 = \frac{9}{10} \times 0.48 = 0.432 \text{ in.}$$

Thus from Eq(3): $H = 5.25(1.432) + 1.875 = 9.393$ in.

(b) To find the stress due to the applied force of 8400 lb, Figs. 3 and 4 is used. Line II lists a load of 15,330 lb at a stress of 100,000 psi. Since the stress is proportional,

$$S_2 = \frac{8{,}400}{15{,}330} \times 100{,}000 = 54{,}800 \text{ psi.}$$

(c) The working deflection is: $9.393 - 8.0 = 1.393$ inches and the deflection factor becomes:

$$\delta_2 = \delta \times \frac{S_2}{S} = 0.48 \times \frac{54{,}800}{100{,}000} = 0.263$$

Thus the deflection per active coil can be found from Eq(5), $f = 0.263 \times 1.25 = 0.329$ and the number of active coils are: $1.393/0.329 = 4.23$.

(*Continued on page 205*)

You're always right with AUTO-LITE

Industrial Wire & Cable

• The quality of Auto-Lite Wire and Cable is the result of nearly 40 years of experience, research and advanced laboratory tests. This, plus the tremendous output possible in Auto-Lite plants at Port Huron, Michigan and Hazelton, Pa., makes Auto-Lite a logical source of supply for wire to fit every need. Address inquiries to:

The Electric Auto-Lite Company
Wire and Cable Division
Port Huron, Mich. Hazelton, Pa.

MAGNET WIRE
Round Single and Heavy Formvar
Round Enameled and Formvar Single Cotton. Round Double Cotton
Round, Rectangular and Square Double Paper Single Cotton
Round, Rectangular and Square Vega Chromoxide
Tinned Copper Wire
AUTOMOTIVE
Ignition Cable Neoprene Sheathed
Low Tension Cable Color Combinations
Battery, Starter and Ground Cable
AIRCRAFT
Plastic Insulation—Special "B" Cotton Braid—"CA" Lacquer
APPROVED UNDER SPECIFICATION NO. AN-JC-48

WIRE & CABLE • DIE CASTINGS • PLASTICS • INDUSTRIAL THERMOMETERS

Design Charts for Large Compression Springs (continued)

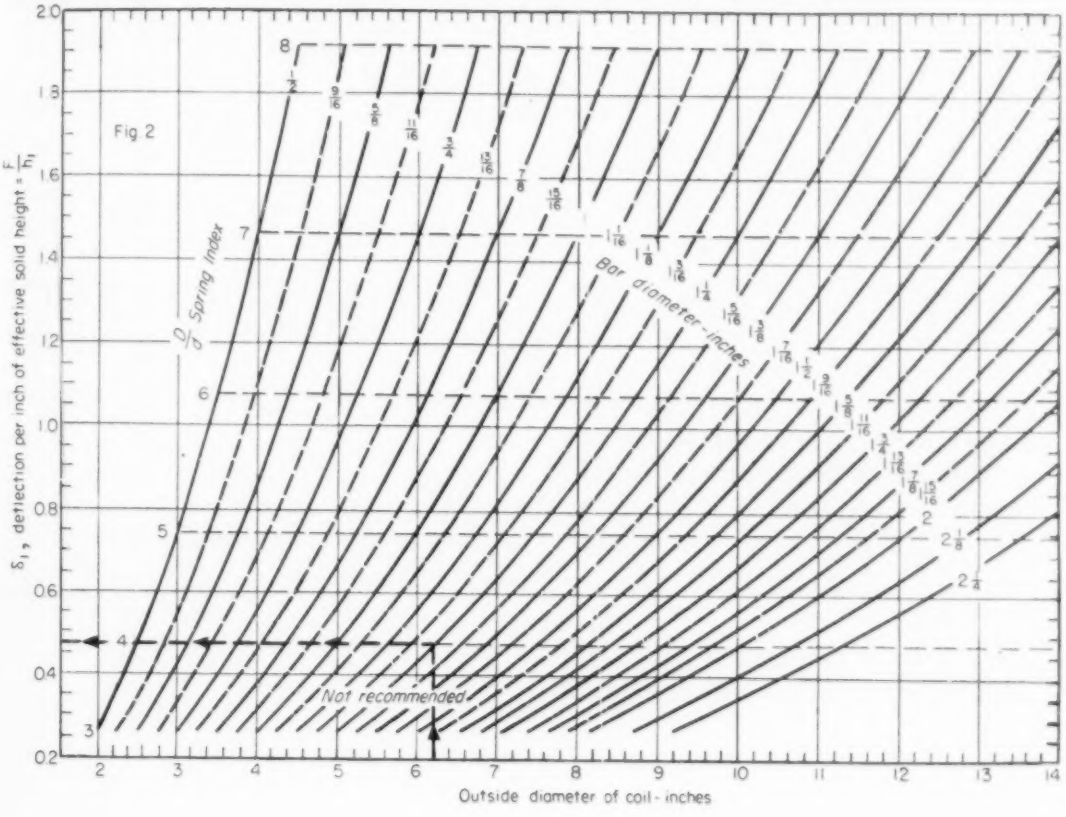


Fig 2
δ_1, deflection per inch of effective solid height = $\frac{F}{h_1}$
D/d Spring index
Bar diameter - inches
Not recommended
Outside diameter of coil - inches

$$H = \left[h_1(1+\delta_1)\right] + 1.5\,d \qquad (3)$$

$$h = \frac{H_1}{1+\delta_1} + 1.5\,d \quad \text{or} \quad h = \frac{F}{\delta_1} + 1.5\,d \qquad (4A)\ (4B)$$

$$f = \delta_1 d \qquad (5)$$

$$F = h_1 \delta_1 \qquad (6)$$

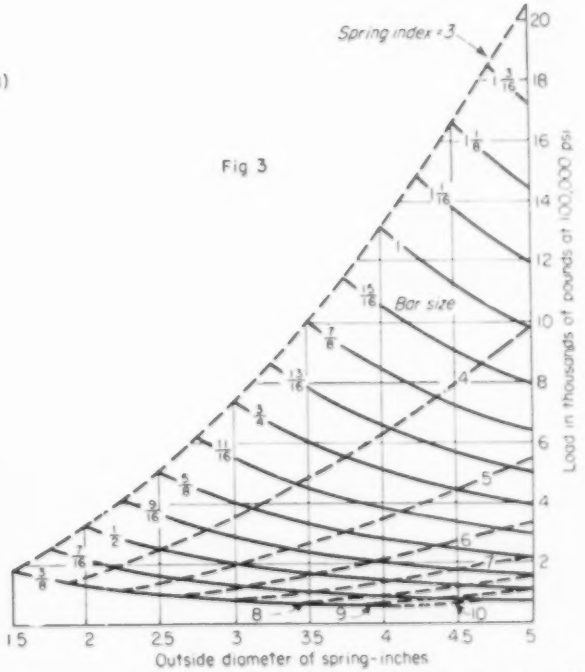
$$\delta_1 = \frac{H_1}{h_1} - 1 \qquad (7A)$$

$$= \frac{f}{d} \qquad (7B)$$

$$= \frac{F}{h_1} \quad \text{(see Fig 2)} \qquad (7C)$$

H = Free height
H_1 = Effective free height = $H - 1.5d$
h = Solid height
h_1 = Effective solid height = $h - 1.5d$
F = Total deflection
f = Deflection per active coil
d = Bar diameter
D = Mean coil diameter
δ = Deflection per solid height at 100,000 psi
$\delta_1\delta_2$ = Deflection per solid height at other stress values

Fig 3



(Continued on page 207)

4 facts*

ABOUT TYPE 430 STAINLESS STEEL

*1 **Type 430 is available NOW**

There are no government restrictions on end uses for Type 430 stainless steel—one of the oldest standard stainless types. Other chromium types are also available. Only nickel-bearing stainless steels, such as well-known 18-8, are restricted under NPA Order M-80.

*2 **Supplied in ALL FINISHES**

Armco 17 Stainless Steel sheets, strip and plates are supplied in the same gages, sizes and finishes as 18-8.

*3 **Has many uses**

Type 430 is normally specified in many applications, and its use has been growing in recent years. Under present conditions it will also serve as a satisfactory alternate for Type 302 in a wide range of products.

However, Type 430 should not be considered a "cure-all." In many applications it may not be entirely satisfactory—but still the best metal available today.

*4 **Readily fabricated**

Almost any product now made of stainless steel can be fabricated of Type 430. It may require greater care and more operations at higher cost—one big reason why Type 302 is always preferred for many products.

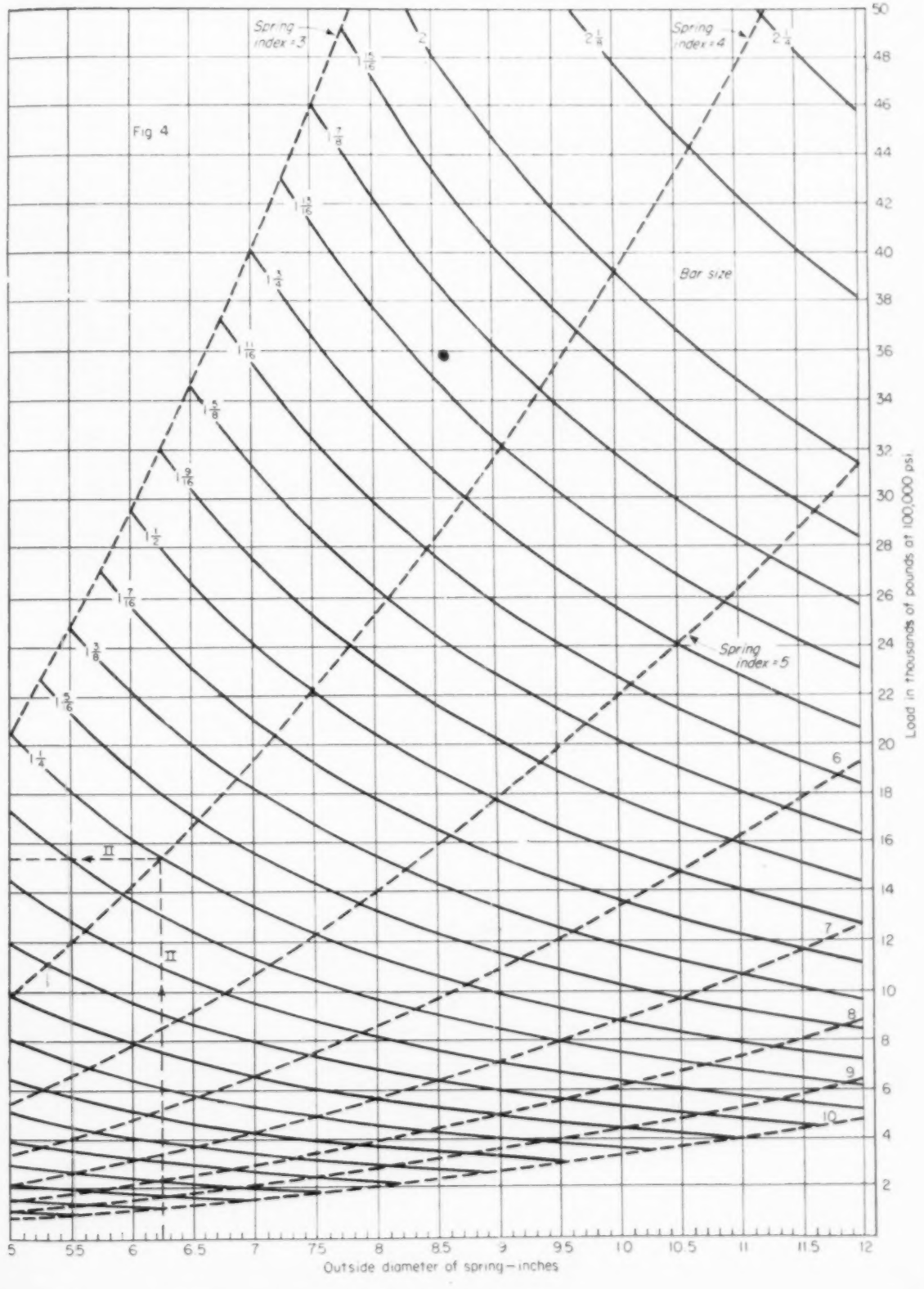
Forming characteristics are about the same as hot-rolled steel, but welds are less ductile and less resistant to shock loading. With modifications in drawing practice, Armco 17 will take difficult draws.

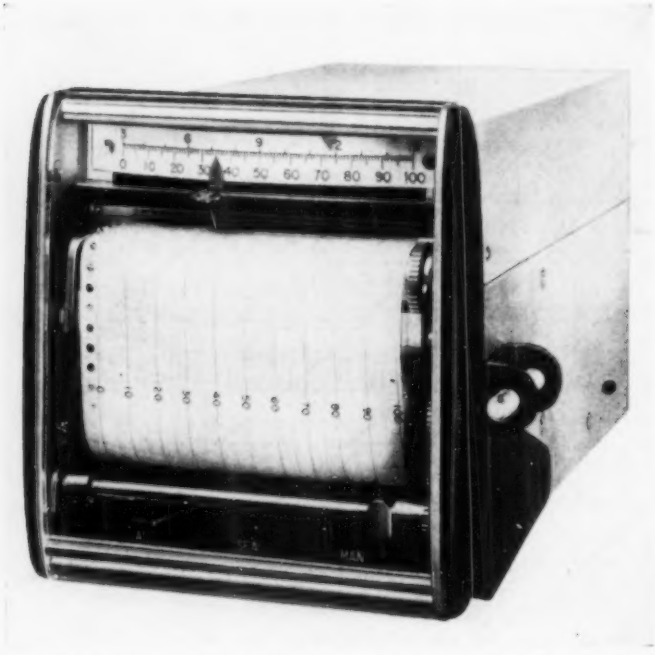
To help you determine whether or not Type 430 is suitable for your products, we have just published a new folder listing satisfactory and unsatisfactory uses. A bulletin on "How to Fabricate Type 430 Stainless Steel" is also available. Write us, or ask your nearest Armco Distributor for free copies.

ARMCO STEEL CORPORATION ARMCO

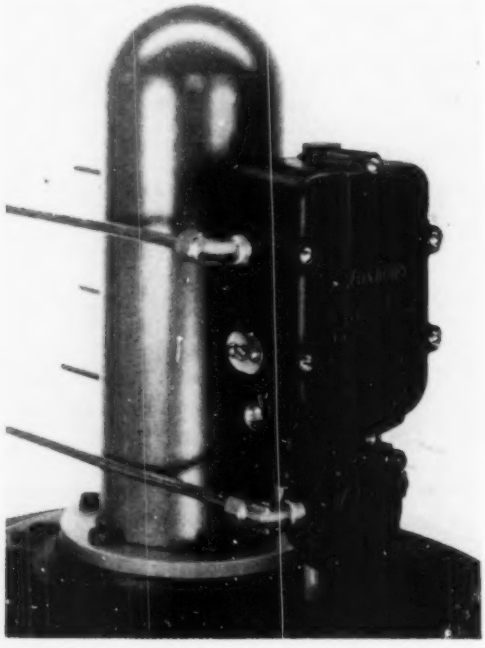
1552 Curtis Street, Middletown, Ohio • Plants and sales offices from coast to coast • Export: The Armco International Corporation

Design Charts for Large Compression Springs (continued)





THE MODEL 5312 STD CONSOTROL RECEIVER RECORDER with remote set, and "one-two" transfer. This unit has built in facilities for adjusting the control point of any controller that may be remotely located.



THE MODEL 59 V/M, pneumatically set controller mounts directly on the valve motor case, eliminating transmission line lag between the controller and valve.

New Instrument Indicates, Records, Controls

The model 5312-STD consoltrol recorder is a receiving instrument equipped with a micrometer control point setting device, automatic-manual transfer switch, and an indicating scale to show control point setting and valve motor pressure. Designed for use with any standard (3-15 psi) pneumatic measurement transmitter, and any standard pneumatically set receiver-controller, it has the following features: (1) Drift-free control point, using precision pneumatic transmitter; (2) Positive control point setting with micrometer drive, and no backlash; (3) Easy-to-read 4 in. horizontal scale that gives both a continuous accurate indication of valve motor pressure and control setting; (4) No set knobs, no confusion as to direction of rotation; settings are lever-operated, easily accessible; (5) Simple transfer switch gives one-two operation; (6) Accessible zero adjustment for all elements.

All connections are $\frac{1}{4}$ in. female N.P.T. including 20 psi air supply for the set point transmitter. A $\frac{1}{2}$ in. electrical conduit connection is included. All connections are accessible at the back of the instrument and are identified.

There are three matched 3-15 psi elements in the instrument. One receiver element responds to the transmitted measurement, and positions the recording pen. The second receiver element positions an indicating pointer on a 3-15 psi scale to show valve motor pressure. The third element is a precision transmitter unit, the output pressure of which is determined by the position of the manually set lever on the 0-100 set point indicating scale. This unit supplies set point pressure for automatic operation and valve motor pressure for manual operation. When pressures in the three matched elements are equal, the pen and the two indicating pointers are in line. This simplifies check calibration.

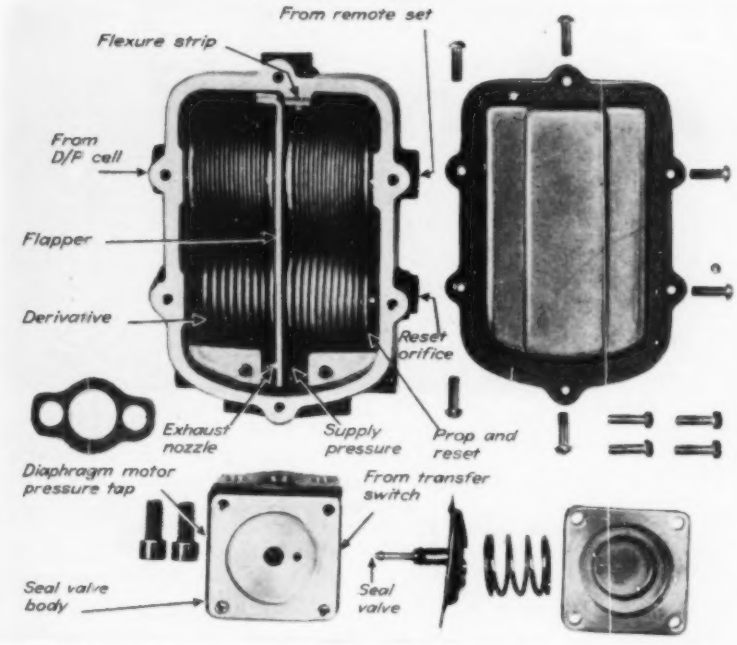
A reversible manifold is located on the back of the recorder. When the recorder is used with a combination controller and seal valve, (as is required when the controller is field-mounted in the process area), the set and seal controller connections are made to this manifold. When used with a panel-mounted controller without seal valve, the manifold is reversed by turning it end-for-end; the set, feed-back, and output connections from the controller are made to the manifold. In either case, valve and measurement connections are made directly to the back of the recorder.

The recorder also has: (1) A 4 in. wide, 30 day strip chart, having the same scale length of conventional 12 in. circular charts; (2) Easy-reading horizontal chart scale (chart moves vertically); (3) Almost 6 hr of chart record showing at all times, without opening instrument door; (4) Thumb wheel to unwind chart to look back at any amount of record.

The model 59 V/M (valve mounted) consotrol Flow Controller

MATERIALS - PARTS

SPECIFIED BY PRODUCT ENGINEERS



A BREAKDOWN VIEW OF the model 59 V/M flow controller which operates correctly without adjustments regardless of valve, orifice, or line sizes. Control point setting, and automatic-manual transfers are made on the control room panel.

has been designed for use on liquid flow control applications where the measurement is transmitted from high speed differential pressure transmitter, and installed on an orifice in the same line as the control valve. It is a pneumatically set controller of the force balance type, which is arranged for mounting directly on the valve motor.

This controller has fixed proportional band and reset values, made possible by the narrow range of characteristics of liquid flow control systems having low time constants. Features are: (1) Only one moving part, the flapper (which moves only a few thousandths of an inch); almost no maintenance on a mechanism said to be foolproof; (2) Fast speed of response to change in measurement signal; (3) Control action can be reversed by interchanging the measurement and set connections; (4) Sealed against surrounding atmosphere; (5) Easily connected to valve motor (supply connection), using short pipe nipple; (6) Optionally available with integrally-mounted seal valve, providing for manual operation when controller is field mounted; (7) Controller case has $\frac{1}{4}$ in. N.P.T. connections for 20 psi air supply, receiver element, control set point element, and exhaust; seal valve used with the same size connections for operation of seal valve diaphragm, and for valve motor pressure indication.

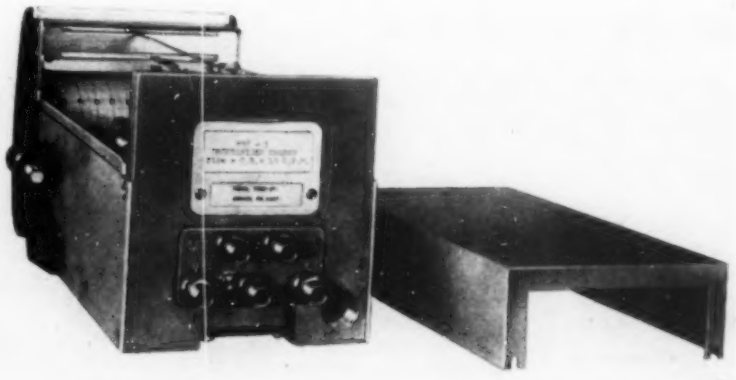
The flapper is flexure-pivoted and positioned between the supply and exhaust port nozzles by the forces exerted on it by the four bellows. Since the set point and measurement bellows are the same size, any unbalanced force between them represents the difference between measurement and set point pressures.

The proportional-reset bellows, acting upon the flapper at a different lever length, opposes any such unbalanced force by an amount determined by the difference between its external and internal pressures. The interior of the controller case is always at the controller output (valve motor) pressure.

If the controller has come to balance with 9 psi output pressure, the interior of the proportional-reset bellows will be at 9 psi, and the flapper will be about midway between the supply and exhaust nozzles. Under this condition, the proportional-reset bellows will exert no force on the flapper. Any pressure unbalance between the measurement and set point bellows will change the flapper position until sufficient pressure differential is developed to oppose that unbalance.

The interior of the proportional-reset bellows is connected by a restrictive passage to the controller output pressure (within the controller case). This restrictive passage serves as the reset resistance, which is to prevent control point drop. Therefore, pressure on the outside of the proportional-reset bellows gives proportional action, and pressure variations inside the bellows gives the reset action.

The Foxboro Co., Foxboro, Mass.



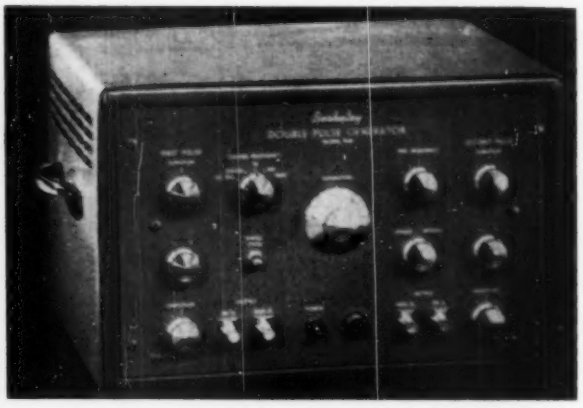
A rear view of the model 5312 consotrol recorder showing the reversible manifold. When the recorder is used with a combination controller and seal valve, the "set" and "seal" connections are made here. Unit has single switch automatic-manual transfer.

CONTINUED ON PAGE 210

Generator Produces Single and Double Pulses

The model 903, double pulse generator, is designed for general laboratory work and will produce either single or double pulses, such that the amplitude and width of each pulse is continuously and individually variable. Spacing between pulses is controlled by means of a calibrated front panel knob. The instrument is suited for designing and testing amplifier circuits, gating, and gating control circuits, high speed scalers, and wide band amplifiers.

The unit can produce either positive or negative pulses. The amplitude of negative pulses is individually variable from 200 v max into a 1,000 ohm load and 10 v max into a 50 ohm load. The amplitude of positive pulses is individually variable from 50 v max into a 1,000 ohm load and 2.5 v max into a 50 ohm load. Separation of the pulse pairs is continuously variable from 0 to 10 microseconds and can be read directly on a calibrated knob on the front panel. The rise time of the pulses is 0.035 microseconds and decay time less than 0.15 microseconds. Pulse width is variable from 0.1 to 1.8 microseconds. The repetition rate of either single pulses or pulse pairs is internally controllable from 1 to 1,000 pulses per sec. Single cycle pulses or pulse pairs may be obtained by means of a push-button. The unit can be driven from an external generator at any rate up to 1,000 pulses per second. A 30 v positive scope trigger is available from the model 903 pulse generator. This will occur one microsecond before the first pulse.



The model 903 double pulse generator consists of two pulse forming circuits with an integrating network to provide a time delay between pulses. The internal rate generator permits control of the repetition rate and the output circuits provide mixing and selectable output impedance levels. The pulse shaping circuit consists of a delay line 1.2 microseconds long which is discharged through its impedance when a thyratron is fired. By this means it is possible to obtain a very fast time rise.

Berkeley Scientific Corp., 2200 Wright Ave., Richmond, Calif.

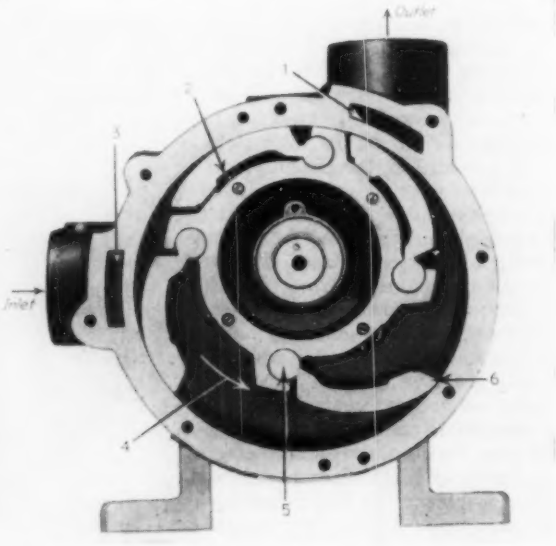
Wing Type Air Pump Takes Up Its Own Wear

The interior construction of the 4-wing type is so arranged that the wings take up their own wear. They wear uniformly, regardless of age, and maintain good contact with the inner cylinder wall.

The wings are hinged to the piston, and the centrifugal force insures the close contact with the cylinder wall. Each wing, as it reaches the top, is kept close to the cylinder wall by a pressure stud, which prevents the air from returning to the intake. This gives a perfect compression or positive vacuum at all times.

Because the parts of the pump are machined to close tolerances, no gaskets or other packing is ever required.

Features: Air from cylinder through the by-pass in the cylinder head enters slot no (1) on its way to the outlet above. No opening in curved inner surface gives quiet operation; Enclosed stud (2) in piston holds wing close to cylinder at top on largest pumps; Air coming in at inlet (3) at side comes through this slot into cylinder head by-pass and then into cylinder. No opening in curved inner surface means quiet operation; (4) direction of rotation, showing how extended wing scoops up the air at the inlet and carries it around to the outlet; (5) easy-action hinge permits wing to open and close by centrifugal force; (6) wing and cylinder surfaces become hard and glassy, which gives a good fit, and positive pressure or vacuum. Inlet and outlet connections are threaded for use with any standard pipe.



The pumps occupy a small space, and are designed for applications where mercury vacuums are required up to 29 in. and pressures up to 25 lb. psi.

Leinman Bros., Inc., 146 Christie St., Newark 5, N. J.

CONTINUED ON PAGE 213

"Moving" examples of **Flexible Connector jobs**

EXTENSION "FINGERS" FOR TIGHT SPOTS Have you ever dropped a screw or small part in a tight spot where your own fingers can't get at it? Then you'll appreciate these mechanical "fingers" which work around corners, even in a figure "s." They stay put, they grip and twist. Made by Aircraft Specialties, Inc., Lapeer, Michigan, from American 7/32 in. I.D. Lamp Arm Tubing.

The right move is to use American Flexible Metal Hose or Seamless Tubing wherever connectors must be flexible, absorb vibration, stand punishment of almost any kind. For close connections, for misaligned ports, for resisting heat, pressure and corrosion, let us suggest the right connector for the job.

Bulletins SS-50 and CC-300 contain information you ought to have about these versatile products. For your copies, write The American Brass Company, American Metal Hose Branch, Waterbury 20, Connecticut. In Canada: The Canadian Fairbanks-Morse Company, Ltd. Distributors in all key cities.

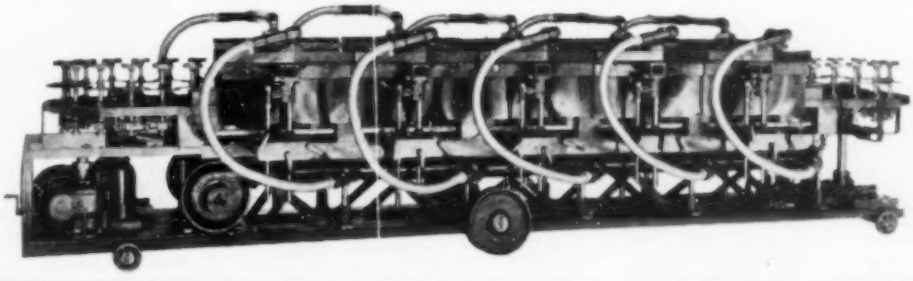
wherever connectors must move...

American ANACONDA

FLEXIBLE METAL HOSE AND TUBING

MOVES WITH VIBRATION — Lubricant is carried under pressure through 1-in. and 2-in. American Flexible Metal Hose Connectors to bearings and rolls of this 18-in., 4-high rolling mill. Vibration can never break these connectors.

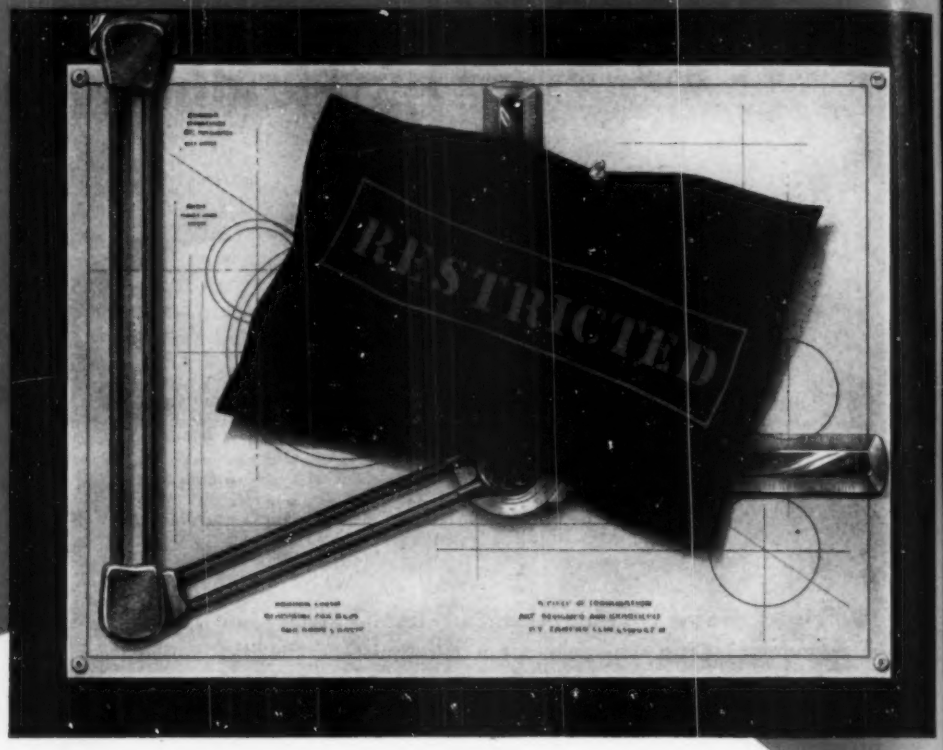
TO "COOK" A SMOOTH DISH — American Flexible Metal Hose conveys gas to burners of this A. B. Knight glazing and polishing machine for finishing pressed tumblers, plates and dishes. Flexible connectors permit burner adjustment to products of varying size and shape.



C/R

THE SEAL OF COOPERATIVE RESEARCH

Is YOUR PRODUCT still on the drawing board?...



...NOW is the time for SIRVENE

Yes, drawing board time is Sirvene time if your new product will require diaphragms, boots, gaskets or other critical pliable parts of unusual or intricate design. Many a seemingly "impossible" critical parts problem . . . completely different in physical properties and operational characteristics . . . has been satisfactorily solved by Sirvene through early C/R cooperative research and engineering.

Sirvene is the name for Chicago Rawhide's scientifically compounded elastomers (synthetic rubber) which withstand extreme heat or cold, dryness or excessive moisture, oil, water, chemicals or any other conditions where ordinary pliables fail.

Whatever your need, Sirvene research and engineering will create a special design, develop a new compound, then mass-produce the necessary part to your specifications with micrometric accuracy. You'll have the *exact* degree of flexibility, hardness, resistance to temperatures, fluids, gases, abrasion and wear, or other qualities you may require.

On land, sea and air, Sirvene is serving in thousands of critical and difficult situations. It can do the same for you.

CHICAGO RAWHIDE MANUFACTURING CO.

1299 Elston Avenue SIRVENE DIVISION Chicago 22, Illinois

The cooperative research and engineering services which C/R has provided in producing special Sirvene synthetic rubber parts for leading manufacturers, are also available to you. We will be pleased to send you any further information you wish. Brochure on request.

C/R SIRVENE

SCIENTIFICALLY COMPOUNDED ELASTOMERS

sirvis

Mechanical Leather Products

Boots, diaphragms, packings and other products give dependable service under difficult operating conditions.

PERFECT Oil Seals

C/R seals are used in more motor vehicles, farm implements and industrial machines than any other shaft-type sealing device.

Representatives in These Principal Cities

Boston • New York • Syracuse
Philadelphia • Pittsburgh • Cincinnati
Cleveland • Detroit • Peoria • Minneapolis
Kansas City • Houston • Los Angeles
San Francisco

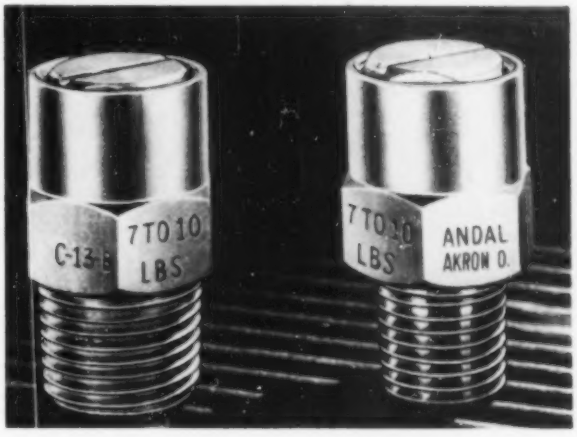
Accurate Control of Low Pressure Gases

The C-13 relief valve which has been designed to give positive, accurate control of gases and vapors at a pre-set range of 7 to 10 psi, may be used on rigid containers such as storage tanks, and aircraft engine shipping enclosures.

Using noncorrosive parts and standard pipe thread fittings, it will withstand the effects of weather, and meets the government salt spray test standards.

The valve is set to operate at pressures in the 7 to 10 psi range by means of an adjusting screw located at top. The unit is available in three models having $\frac{1}{4}$ in., $\frac{3}{8}$ in., or special pipe thread. Standard length of the valve is $1\frac{5}{16}$ in., but special lengths can be furnished upon request. Overall diameter is $\frac{3}{4}$ inch. Special pipe threads or gasket and nut mounting can be supplied readily to specifications. Having wide application, the valve can be furnished in brass, steel, stainless steel or other construction as specified.

Andrews-Alderfer Co., 1118 Home Ave., Akron 10, Ohio



Octal Type Connector Saves Critical Material

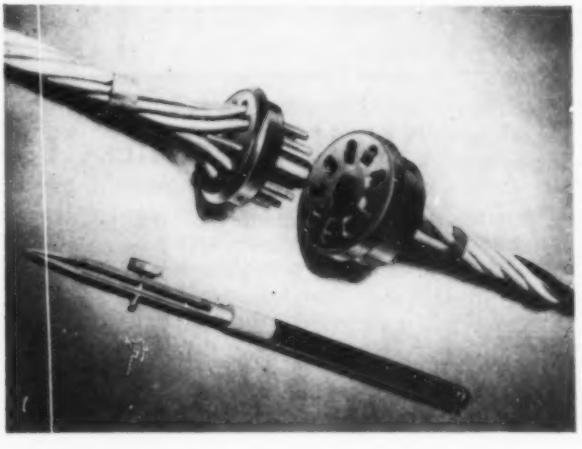
A new octal type 9 pin connector, 209FEC, and plug, 109C, for use with TV adapters, UHF converters or wherever a rugged, small connector is needed has long leakage paths giving a good breakdown rating. Top connected contacts use a minimum of critical material, but are well designed for low resistance and long life.

Because this connector has no waste, more units can be made out of the same amount of material than with other designs, therefore stretching CMP allotments.

The basic construction of the 209FEC is: no disks, wafers, or rivets; just the molding, contacts and wire.

Inside the connector are: leads attached directly to the contact—no projecting solder terminals; 100 percent molded insulation around each contact and lead; each lead has individual strain relief; wire tip crimped firmly an eliminating danger of cold solder joints.

Alden Products Co., 117 N. Main St., Brockton 64, Mass.



Filter Removes Microscopic and Radioactive Particles

Originally developed for the Atomic Energy Commission and now available for commercial and industrial use, this new filter is said to give absolute removal of all measurable dust, smoke, fumes, spores, radioactive particles, and other microscopic foreign matter from the air. All filters are tested after production for at least 99.95 percent efficiency by a special testing device using a controlled smoke generator to produce smoke particles three-tenths of a micron, or 3/250,000 in. in diameter. The finest particles are automatically recorded and measured on photoelectric cells in the testing chamber by means of light reflected from the particles.

The heart of the filter is said to be in the paper made from treated paper pulp into which fine asbestos fibers have been introduced.

Filters are produced in five sizes from 15 to 850 cfm. Life expectancy under normal conditions with proper pre-filtering is estimated at one to three years. The filters are said to be light, compact, and easily installed, and have a low ratio of pressure drop of efficiency.

The dimensions of the frame without rubber gaskets for the 850 cfm model are: 24 in. high, 24 in. wide and $11\frac{1}{2}$ in. deep. The smallest filter of 15 cfm measures 8 in. high, by 8 in. wide, and $3\frac{1}{16}$ in. deep. The filter has a life expectancy of three years with proper prefiltering under normal conditions. Easily removed and replaced when exhausted. It can be burned.

The Cambridge Corp., 350 S. Geddes St., Syracuse, N. Y.

CONTINUED ON PAGE 214

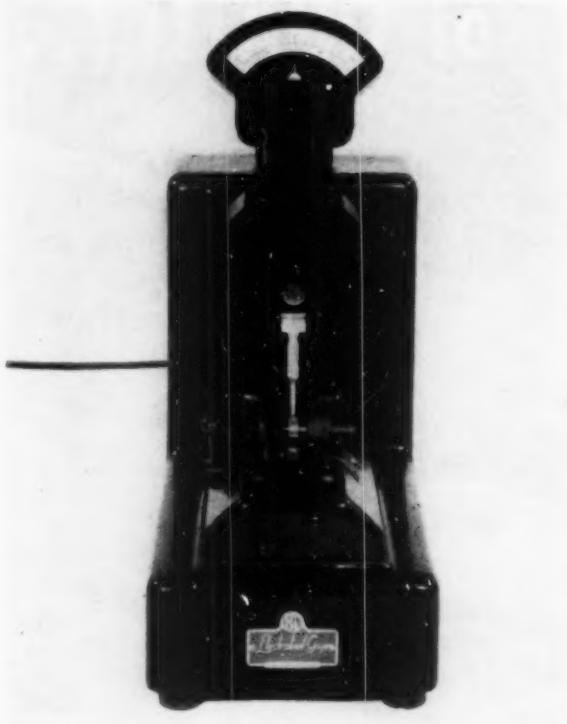
Gage Measures Radial Play of Ball Bearings

A comparator for measuring the radial play of ball bearings has been developed for gaging small precision instrument type bearings. It is known as the electrolimit internal clearance comparator-lever type, and with interchangeable tooling it will handle bearings from $\frac{3}{32}$ in. bore to $\frac{1}{2}$ in. bore.

The principal part of this comparator is the C-shaped sub-assembly. The bottom of this assembly is fitted with an arbor that holds the bearing vertically and securely by its inner ring so that the outer ring is free to move according to the amount of radial play. An electrolimit gage head is attached to the upper portion of the C-frame so that its diamond-tipped gaging spindle bears against the top of the outer bearing ring. This presses the outer ring to the down position with all clearance at the bottom. At this point the first of two comparative readings is taken.

To get the second reading, the entire C-frame is tilted downward on pivots which support it over a sub-base. The bottom of the outer ring then contacts the stationary anvil. This presses the outer ring upward on the arbor so that all clearance is at the top. Here a second comparative reading is taken. The difference between the two readings represents the amount of radial clearance in the bearing assembly.

The frame is tilted by a lever operated cam to bring the bearing in and out of contact with the stationary anvil. The frame is counterbalanced in such a way that the bearing clearance is closed with a pressure of eight ounces whether it is being gaged in up or down position.



Pratt & Whitney, Miles-Bement-Pond Co., West Hartford 1, Conn.

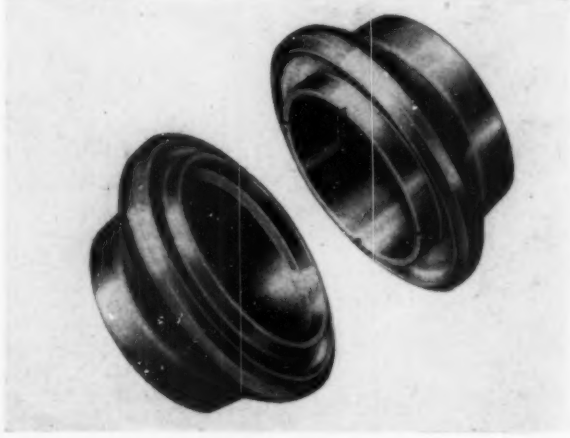
Scale Free Welded Pipe Coupling

The Tube-Turn SF (scale free) welding coupling now makes possible the elimination of damaging welding scale from piping systems.

The welding coupling consists of two forged halves, with the ends of the hubs prepared for welding fittings of corresponding sizes. When the two halves of the coupling are brought together, the tongue of one slips into the groove of the other. A circumferential cavity directly beneath the welding area prevents burn-through or the formation of icicles in the interior. The cavity also insulates the interior from the welding heat and prevents scaling.

The advantages of the SF coupling are: (1) the tongue and groove arrangement makes piping easy to align; (2) the hubs of the coupling are short and any scale or protrusions formed by the two attachment welds can be removed before the coupling is connected; (3) there is no scale to damage valves, traps, pumps, instruments and other equipment; (4) penetration is obtained without the danger of burn-through or the formation of icicles; (5) the coupling can be taken apart when piping is to be disassembled, and re-used; (6) the coupling joint is smooth, reducing pressure drop; (7) maintenance costs are reduced.

The coupling may be used in connecting piping designed to carry hydraulic fluids, high pressure steam, compressed air, chemicals, lubricating oil and fuel oil. It is available in sizes from $1\frac{1}{4}$ in. through 12 in., and in carbon steel, stainless steel, aluminum and other metals and alloys.



Tube Turns, Inc., Louisville 1, Kentucky

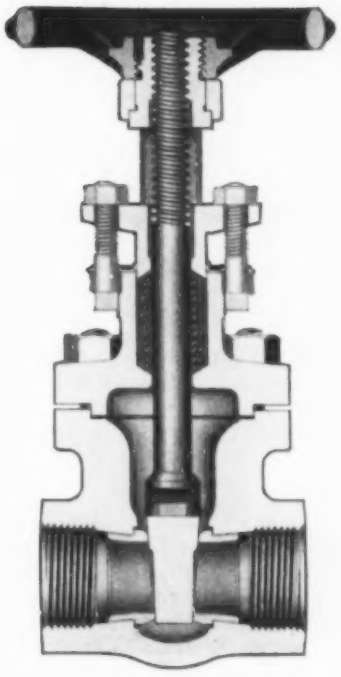
CONTINUED ON PAGE 218

To save yourself time and trouble... Specify piping from your CRANE Catalog

Suppose you're writing piping specs for this *Fuel Oil Pumping, Heating, and Transfer Unit.* You greatly simplify your job when you reach for your Crane Catalog. In it you'll find—and quickly—an unequaled selection of valves, fittings, pipe and accessories.

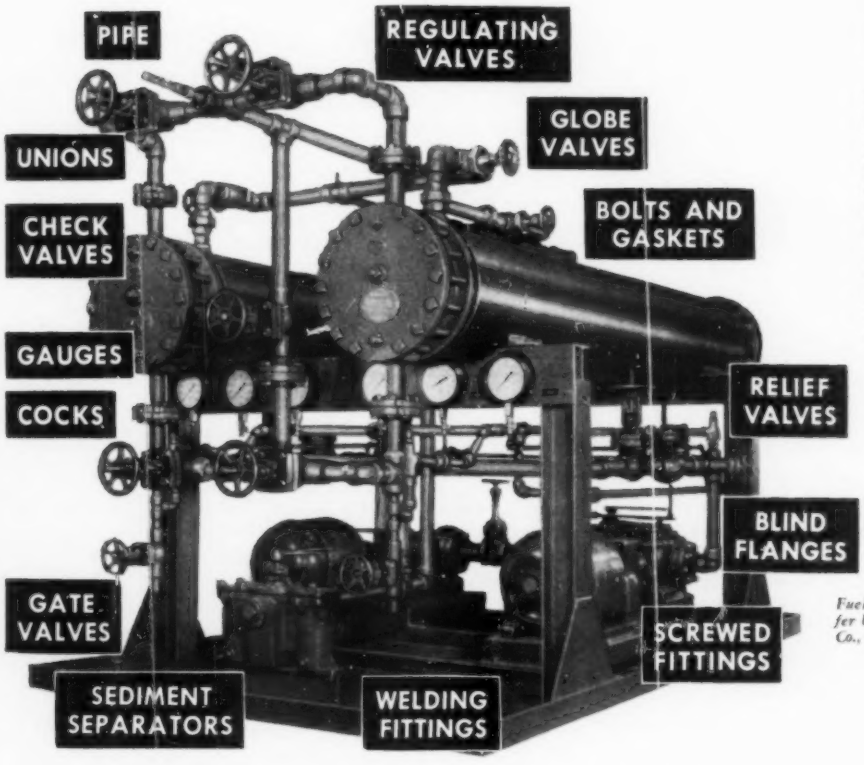
Information about every item is complete. When you check on a valve or fitting, you get all its dimensions; tabulated pressure and temperature ratings; design, material, and construction details; and a full listing of service recommendations. There's an abundance, too, of general engineering data helpful in designing piping systems.

Today, when work loads on machinery are heavier than ever, the name Crane gives your product added value. For experienced buyers know that Crane Quality in piping materials means utmost dependability.



FOR OIL OR OIL VAPOR *services at temperatures over 500° F. and up to 1000° F., and for most corrosive and unrefined oils regardless of temperatures, Crane recommends No. 3607X 600-Pound Small Steel Wedge Gate Valves. Exelloy to Exelloy Trim. Bolted bonnet. O.S.& Y. Screwed, socket-welding, or flanged ends. Sizes: ½ to 2-in. See your Crane No. 49 Catalog, p. 225.*

YOU SPECIFY IT... CRANE SUPPLIES IT...
PIPING EQUIPMENT FOR EVERY DESIGN



Fuel Oil Pumping, Heating, and Transfer Unit by Enterprise Heat and Power Co., Chicago, Ill.

CRANE CO.

General Offices:
836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

Torque And Rotational Speed Read Simultaneously

A dynamometer for fractional horsepower applications has been developed which gives a simultaneous reading for torque and rotational speed. This device comprises a standard PM 2 hysteresis brake mounted in low friction ball bearings with a counterweight attached. Torque is measured directly. Speed is measured by means of a salient pole generation.

The controls located on the front panel include a power supply switch, a rheostat for adjusting torque and a duel range tachometer switch. The torque and speed recording scales are also located on the front panel. The torque scale gives a reading in ounce inches and is graduated with divisions of 5 oz-in. and sub-divisions of 2.5 oz-inches.

Rpm is taken from either of the two graduations on the speed scale. One scale is graduated with divisions of 50 rpm and reads to 4,000 rpm. The other scale is graduated with divisions of 100 rpm and reads to 10,000 rpm.

The maximum hp to be measured by the dynamometer is 0.16 hp when using the 0 to 4,000 rpm scale and 0.40 hp when using the 0 to 10,000 rpm scale. Maximum dissipation for 3 min is 90 watts; continuous rating is 25 watts. For maximum power absorbtion at 0.40 hp, the dynamometer should not be energized for more than $\frac{1}{2}$ minute.

One of the advantages claimed for this dynamometer is its simplified operation. Only one connection is required between the motor shaft and the dynamometer input shaft which is located on the front panel below the torque scale. A flexible coupling, such as a rubber lord coupling, should be used to connect the motor to be tested and the dynamometer shaft.

The advantages claimed for the dynamometer, in addition to the simultaneous torque and speed readings are: (1) All the controls are on the front of the panel; (2) Temperature rise because of dynamometer power dissipation is isolated from the motor being tested: (3) There is only one connection between the motor and the dynamometer; (4) Calibration of torque is not affected by changes in humidity, temperature or speed; (5) Two position switch

for dual range tachometer; (6) No springs are employed, torque readings are positive and accurate within close limits. The unit may be recalibrated for change in bearing drag and windage if testing is to be conducted at wide extremes of speed where high degree of accuracy is required; (7) Salient pole tach generator absorbs insignificant power at speeds in excess of 500 rpm; (8) The inertia of the dynamometer is 310.2 x 10^{-6} slug ft^2 which permits accurate readings of low torque.

Electrical input required to operate the unit is 115 v ac-dc; 250 milliamps; 28.7 w maximum.

Because of the inherent characteristics of the low torque tach generator, the minimum speed for proper readings is in the range of 500 rpm. Other models of dynamometers will be built to measure hp from 1/100 to $\frac{3}{4}$ hp.

Duncan & Bayley, 785 Hertel Ave., Buffalo 7, N. Y

Packing Has Good Rubber And Leather Properties

A type of rubber-impregnated leather packing that does not lose resiliency and flexibility, even after several years of service, recently was announced by one of the major packing manufacturers. This is said to be the first packing that successfully combines the low frictional characteristics and high strength of leather with the sealing ability, resilience, and heat resistance of rubber.

The leather base of the packing is completely impregnated with a synthetic elastamer, and the bond is completed by polymeryation. As a result, the impregnation is not confined to a surface treatment.

A good packing should have high resistance to abrasion and scoring, resist extrusion or cold flow, be capable of operating over a wide temperature range, be non-porous, have scoring, resist extrusion or cold flow, be capable of operating over a wide temperature range, be non-porous, have a low coefficient of friction and long life, and maintain resiliency even after long service. Leather has low frictional characteristics but has the sealing ability and resiliency of rubber. Rubber cold flows and has a high coefficient of friction. The difficulty with the plastic resins is that leather, being a retrafilter, prevents complete impregnation. In this packing, there is about 60 percent take-up. The packing can be squeezed double in the hand, and still return to the some proportions when released.

Other advantages may be summarized as follows:

1. Improved sealing ability, because of the high resiliency factor.
2. Ease of assembling, because of the springiness rubber provides.
3. High resistance to oils and solvents.
4. Resistance to heat as high as 200 deg F.

E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa.

CONTINUED ON PAGE 220

When your problem involves PACKINGS...

here's a Houghton service for you

Machine designers with hydraulic and pneumatic packing problems can tell you why they come to Houghton for engineering aid.

If *you* already have, you'll know it is not only because Houghton packings are reliable to a degree which many say is unequalled. It's also the *plus value* of Houghton's engineering service which you know you can depend on at any time.

We believe we can say with complete assurance that there are practically no hydraulic or pneumatic packing problems that Houghton research either hasn't solved . . . or can help you solve.

We don't intend to stop with the many different kinds of high quality, uniform packings now available to meet practically every condition you may face. New combinations of leather, rubber, synthetic compositions and impregnations will be offered to industry as they are developed to fit special applications—perhaps one of yours!

Consult us on any design problem. Write or call E. F. Houghton & Co., Philadelphia 33, Pa., for the complete aid our engineering staff offers you and your clients.

WRITE FOR PACKINGS BULLETIN . . . IT DESCRIBES

VIM LEATHER PACKINGS — Cups, flange, "U", "V"—flat washers, discs and gaskets—for oil, air, water or gas pressures—in hydraulic or pneumatic equipment, pumps, valves, etc. Engineered for exact needs. Used for all pressures, and temperatures up to 200° F. These packings provide positive action, smooth service, insure long trouble-free life and aid production schedules.

VIX-SYN SYNTHETIC RUBBER PACKINGS—supplementing the VIM Leather line, permit the centralized purchasing of packings for every application. The VIX-SYN line includes homogeneous and fabricated packings, gaskets and adaptors, also "O" rings and VIM Leather back-up washers designed for use with them.

. . . products of

E. F. HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .

Plastic Armored Metal Tubing Has Many Uses

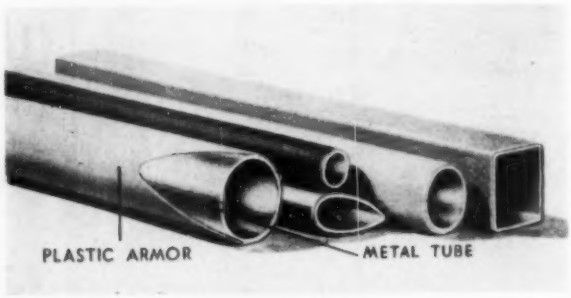
A new plastic armored electrical metallic tubing called DeKoron has a 0.020 in. coating of corrosion resistant vinyl or polyethylene plastic extruded over standard galvanized electrical metallic tubing.

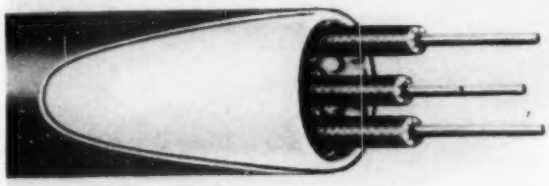
By varying the thickness and composition of the plastic armor, the conduit can be given any desired dielectric properties. The manufacturer claims that the conduit is impervious to the effects of moisture, salt air, acids, alkalies, and grease, and is immune to normal temperature changes.

DeKoron conduit is black but special colors can be supplied. If desired, the plastic coating can be applied over standard rigid conduit instead of galvanized electrical tubing. Standard compression type couplings and connectors wrapped with electrical insulating tape are used.

Also available in square, triangular, oval and other streamlined shapes is the plastic armored metal tubing. Made in a large variety of sizes, colors, and finishes, the new tubing can be used in industrial and consumer applications, such as in furniture, appliances, garment rails, crowd control rails, grab rails, stanchions in transit vehicles, automotive parts, and industrial instrument lines. The tubing will not crack or flake, and can be applied over seamless tubing or tubing with welded, lap or butt seams.

Samuel Moore & Co., DeKoron Tubing Div., Mantua, Ohio





Split-Flange Clamp Prevents Leaks

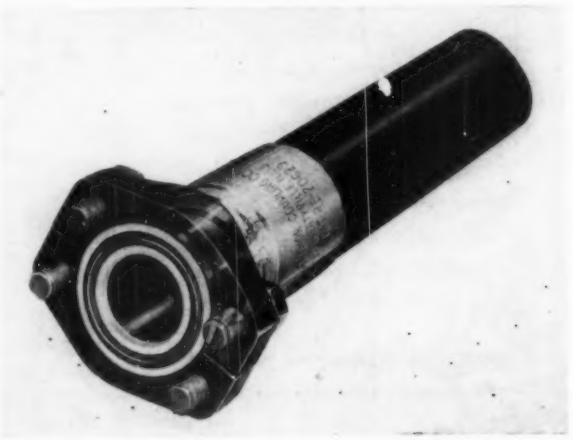
For use in the hydraulic field, a new split-flange type clamp has been developed which is said to prevent leaks, eliminate threaded joints, and is easy to use. A wide selection of sizes is available for use with either clamp or pressed-on type couplings in straight or angle styles for one or two-wire braid hose from $\frac{1}{2}$ in. through 2 in. ID. The clamp may be used for high, medium, or low pressure service, suction return lines, and others.

The seal of this type of clamp consists of an O-ring, which eliminates the need for tapered threads. There is no wedging action to cause distortion in valve bodies, cylinders, or any other piece of hydraulic apparatus.

In assembly, all that is required is a small, automotive-type wrench, giving greater clearance, less effort, and eliminating thread compounds.

The clamp has the bolt centers located on the centroid so that any applied forces are equalized.

Anchor Coupling Co., Libertyville, Ill.



Small Magnetic D-c Switches

A series of small magnetic blow-out switches is now available for use with high voltage d-c circuits, such as those used in industrial equipment, on railway equipment and street cars. With 115 v, and a $\frac{1}{2}$ hp motor load, the inductive load is 5 amps, and the resistive load is 10 amps. With 230 v, and a $\frac{1}{3}$ hp motor load, the inductive load is 3 amps, and the resistive load is 5 amps.

The switches have the same dimensions as the precision a-c switches. The plastic case containing the switching unit measures 1-$\frac{5}{16}$ in. long, $\frac{1}{2}$ in. wide, and $\frac{27}{32}$ in. high, and weighs less than one ounce. The MT-4R pin plunger switches are interchangeable with other pin plunger switches (made by this company) and contained in auxiliary actuator brackets and metal enclosures. The switches available are of the single-pole, double-throw type in the following models: MT-4R pin plunger; MT-4RL leaf actuator; MT-4RL2 roller leaf actuator.

Micro Switch, Freeport, Ill.

CONTINUED ON PAGE 222

Customer Reports:

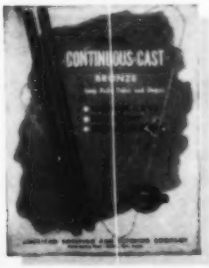
ONLY 250 LBS. REJECTED OUT OF 2,000,000 WITH ASARCO CONTINUOUS CAST BRONZES!

A prominent manufacturer of railroad equipment reports: Only 250 lbs. of Asarco Continuous Cast bronze rejected out of a 2,000,000 lb. experience . . . better properties than other bronzes . . . scrap losses practically eliminated.

There are virtually no rejects when you use Continuous Cast bronzes. The unique Asarco casting process gives you bronze rods, tubes and shapes with fatigue and impact characteristics up to 100% better than those of sand cast bronzes . . . with better tensile strengths, yield strengths and hardnesses . . . with no porosity, no hard or soft spots. Asarco Continuous Cast bronzes are ideal for use on automatic screw machines.

You can get Continuous Cast bronzes made to order in a wide variety of alloys . . . in standard lengths of 12′ . . . lengths 5′ to 12′ on request . . . lengths 12′ to 20′ on special arrangement.

216 sizes of the standard Asarcon 773 bronze (SAE 660) are stocked in 105″ lengths for convenience at warehouses in principal cities across the country. Distributors will cut the warehouse stock to suit your specific requirement . . . *long or short.*



For more data see your Asarco distributor, or send the coupon for a 12-page color catalog that contains complete technical data.

ASARCO CONTINUOUS-CAST RODS·TUBES·SHAPES ®

West Coast Sales Agent:
KINGWELL BROS. LTD., 444 Natoma Street, San Francisco, Calif.

American Smelting and Refining Company
OFFICES: Perth Amboy Plant, Barber, New Jersey
Whiting, Indiana

American Smelting and Refining Company
Perth Amboy Plant, Barber, New Jersey

Please send me a free copy of the new 12-page catalog "ASARCO Continuous-Cast Copper Alloys."

Name..... Title.....

Company.....

Address.....

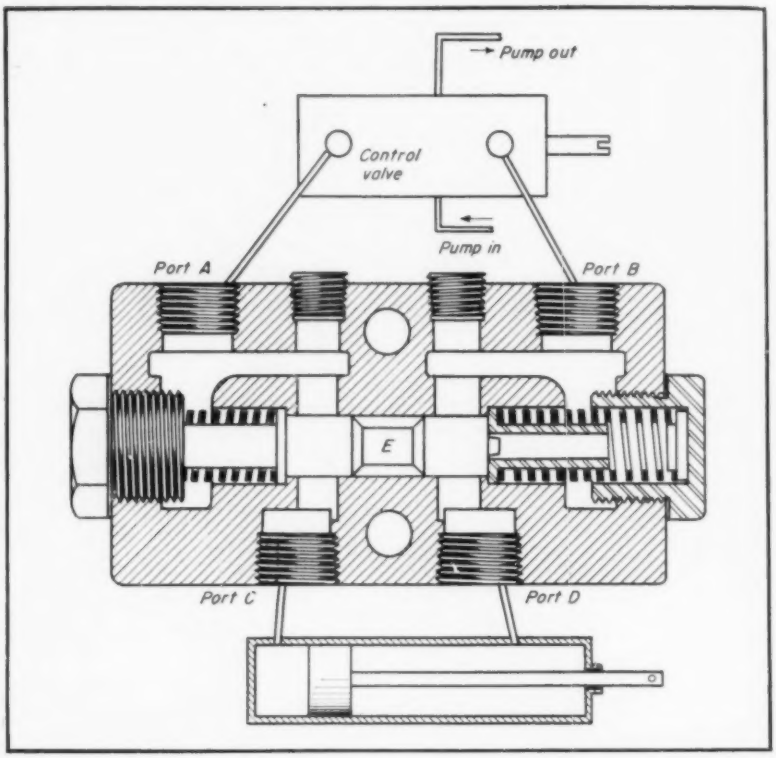
City..... Zone..... State.....

Regulating Valve Eliminates Hydraulic Voids

A new flow regulating valve, model 450, was designed to control the rate of travel of a double acting cylinder by eliminating hydraulic voids in cylinder operation. This would occur in lowering heavy loads where the operating cylinder tends to lower faster than the pump can supply oil to it, or in systems where linkage is such that over center operation is involved.

These valves are particularly designed for controlling movement of actuating cylinders of hydraulically operated cranes, road graders, lift trucks and other equipment where, under certain conditions, the load tends to move the cylinder at a rate such that the pump is unable to supply oil to the power side of the cylinder fast enough to prevent a void being created on that side. Under such a condition loss of control of the load will result unless the rate of travel of this cylinder is controlled.

The flow regulating valve is installed between the cylinder and the main control valve. Control of rate of cylinder travel is maintained by restricting the flow of scavenger oil from the cylinder by means of a plunger which is actuated by the pump line pressure. At the beginning of the operating cycle, pressure at port B is applied to the end of plunger E, moving it to the left and opening the oil passage to and from both ends of the double-acting cylinder. If the rate of cylinder travel is such that the cylinder moves faster than oil can be supplied to it by the pump, line pressure will therefore drop and plunger E under influence of the spring will tend to move over to the right to close down the flow between ports C and A. Line pressure will be restored and control plunger will tend to move to the left again to restore normal flow. This valve is bi-directional and will operate to control flow from either side of the cylinder. It is built with only one size housing but with either $\frac{1}{2}$ in. or $\frac{3}{4}$ in. ports for a maximum operating capacity of 14 gpm. Others have capacities to 25 gpm. at pressures of 1000 psi.



Hydraulic Equipment Co., 1100 E. 222nd St., Cleveland 17, Ohio

Control Center For Motors Up to 200 Hp

A new motor control center, for use wherever two or more a-c motors (up to 200 hp, 600 v) are controlled from a central location, has been developed for use in power stations, public buildings, paper mills, chemical, petroleum, steel, rubber, ore, food, and other processing plants. The unit, designed for accessibility, is pre-engineered, factory wired and assembled, using many standard parts and accessories.

According to the manufacturers, it gives a simplified method of installing and servicing in a central location a-c combination motor starters in NEMA sizes 1 through 5, as well as lighting panels and associated equipment for a group of motors.

The center is designed to withstand short circuit stresses up to 25,000 amps, substantiated by certified laboratory tests. Its sections, each measuring 20 in. deep, 20 in. wide, and 90 in. high, join together to form a strong, free-standing, completely dead-front, NEMA I enclosed, control assembly.

One of the main features of the new design is a 4 in. vertical trough (with cable supports) which runs the full length of each section, giving ample space for wiring. No threading through or fishing is necessary because metal barriers which separate the starter units are easily removed, leaving a continuous wiring trough.

Starter unit replacement is facilitated by positive-action positioning guides which insure correct alignment of starter to vertical bus.

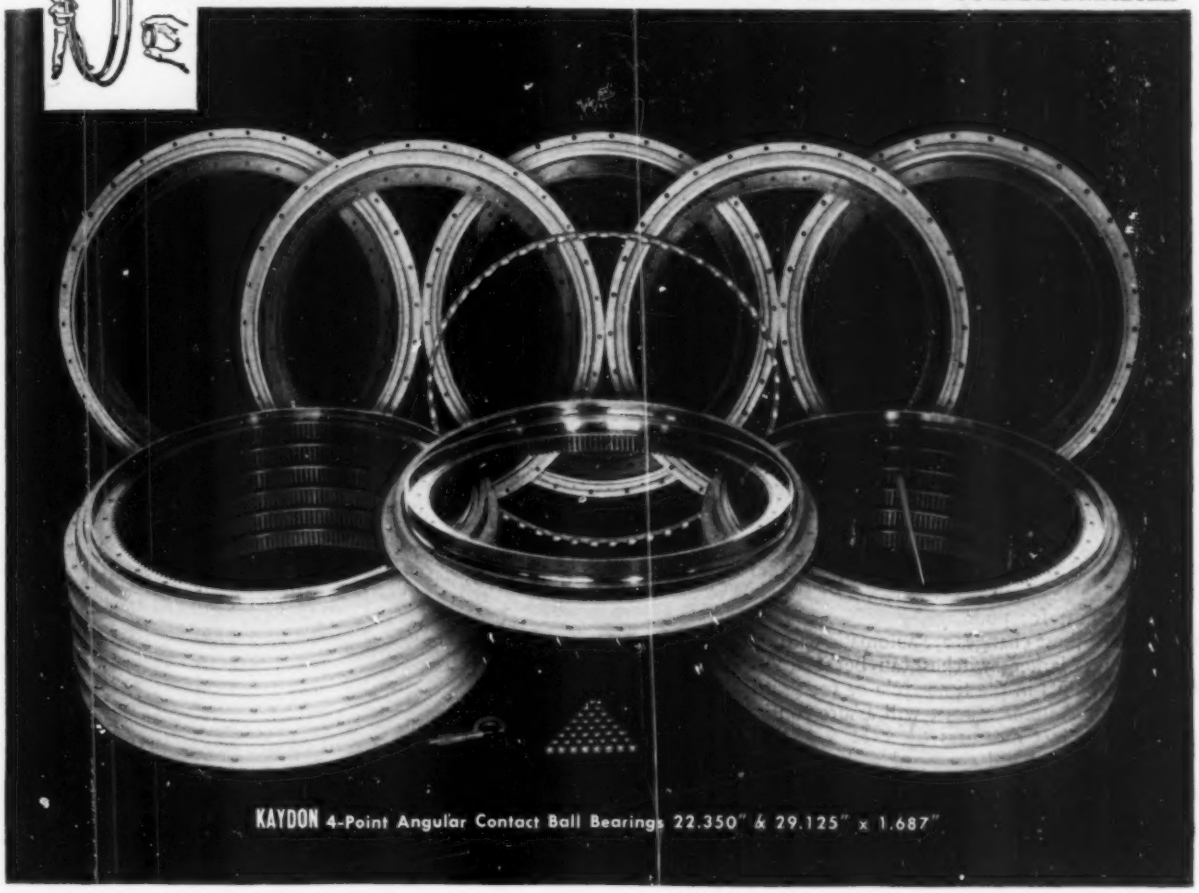
Units may be installed from the front or rear of the section and are designed in even multiples of 14 (height of NEMA size 1 and 2 is 14 in.) offering a variety of arrangements.

General Electric, Schenectady 5, N. Y.

CONTINUED ON PAGE 224

Contact KAYDON of Muskegon

FOR ALL TYPES OF BALL AND ROLLER BEARINGS: 4" BORE TO 120" OUTSIDE DIAMETER



KAYDON 4-Point Angular Contact Ball Bearings 22.350" & 29.125" x 1.687"

Raceways that make machines winners!

Flame-hardening only the raceways of bearings, removes many handicaps in machine design. KAYDON pioneered this technique. Its success has helped make many machines winners!

KAYDON flame-hardening has made possible many special bearings of unusual design, like the 4-point angular contact ball bearings shown here ... with outer and inner races flanged for mounting directly to adjoining machine structures ... with gear teeth cut right on inner race, and inner races fortified by special protective finishes.

KAYDON flame-hardening of bearing-raceways to unusual depths (without through-hardening the races themselves) permits races to be drilled, tapped and gear-cut ... the bearing bulk and weight are greatly reduced ... many surrounding parts may be eliminated ... unusual shapes, very large diameters, extremely thin sections that facilitate mounting are achieved.

These are typical "winning" characteristics of KAYDON Special Bearings. Adaptable to many types of machinery ... maybe *yours!* Call KAYDON.

KAYDON Types of Standard and Special Bearings:
Spherical Roller • Taper Roller • Ball Radial • Ball Thrust • Roller Radial • Roller Thrust • Bi-Angular Bearings

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

PRECISION BALL AND ROLLER BEARINGS

Temperature Setting Changed Automatically

For automatic time control, these control units are supplied with a motor driven cam which will change the temperature setting with time according to a predetermined program. The style 1685 program control unit will take standard simplytrol of the 1630 or 4530 series for temperature ranges from —200 F to 3,000 F.

The temperature setting cam is driven by a clock motor; 12 and 24 hour clocks are standard. Other time cycles can be furnished for shorter or longer periods. Cams are made of light gage aluminum. Radial lines indicate time in hours. The cam pattern is drawn with a scriber which fits on the follower arm. Cams can be cut easily and quickly. Blank cams are inexpensive and the program can be set up in a few minutes.

The instrument illustrated is one of a group that is used to control burnout gas furnaces in an investment casting plant. Starting at 250 F the temperature setting is increased gradually during a period of four hours to 600 F. This preheat drives all moisture from the plaster mold. During the next four hours the temperature is increased to 1,400 F and held there to melt out the wax pattern. The setting is raised to 1,800 F to burn out the residue of wax left after melting. Then the temperature is reduced to 1,400 F which is the correct heat for pouring.

All of these changes are automatic with the 1685 program control. Marker switches can be set to sound alarms at certain points in the time cycle or for shutdown after completion. Automatic reset will assure continuous operation.

The cabinet measures 6½ x 11 x 15 inches. The front door is hinged and equipped with magnetic catch for easy accessability to change cams and start the program cycle. The unit may be used on the bench as a portable control or it may be fastened to the wall or control panel for permanent installations. Knockouts are located in the four sides and back for conduit connections.

Meters calibrated in voltage, current or other values can be used in the control, for time control of special processes.

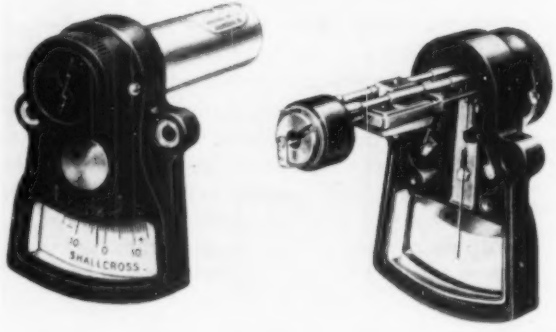
Assembly Products, Inc., Chargrin Falls, Ohio

Interchangeable Galvanometer System

A d-c galvanometer system recently introduced has as its features: simplified construction, lighter weight with a resulting lower cost. Instead of being supported in a large phenolic base, the coil and its mechanism are mounted on sturdy rod supports and protected by a removable aluminum cover only 23/32 in. in diameter. Panel mounting holes are standard, and because of the small diameter of the suspension enclosure, the system can be used as a replacement for most galvanometer systems in common use.

A knurled knob on top of the case permits accurate zero adjustment of the pointer. The knob may be locked by tightening one or both of the screws on each side of it. A slide lock protects the movement from mechanical shock in transit. Known as the type 1951 systems, they are normally supplied complete with magnet, mounting dimensions and hardware for use in new instruments.

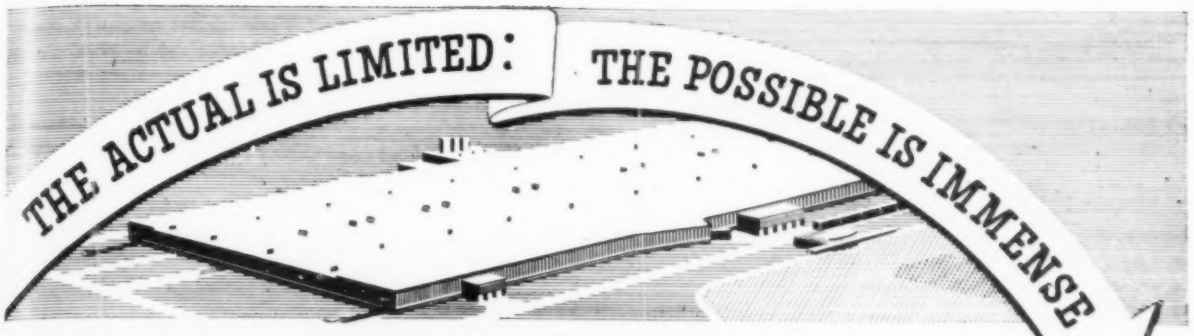
The type 1951 galvanometers are available in 4 types having sensitivities per mm division of 4; 2; 1; and 0.5 microamps respectively. The high sensitivity, sturdy construction, and compact size of the units made them adaptable to bridge and potentiometer circuits, or wherever indication of precise circuit balance is required. Each unit employs the taut-suspension moving-coil principle with a scale calibrated in 15 divisions of 1 mm either side of center.



The mountings permit the galvanometer to be substituted for many of the systems without changing the magnets.

Shallcross Mfg. Co., Collingdale, Pa.

—CONTINUED ON PAGE 226



NEW LINCOLN PLANT CREATED BY INCENTIVE-INSPIRED CO-ACTION IN DEVELOPING POSSIBILITIES IN PRODUCT

© LF Co. 1951

MACHINE BUILDER SIMPLIFIES SERVICE PROBLEMS WITH WELDED STEEL

By **Walter E. Vuchnich**
Welding Engineer
Milwaukee, Wisconsin

IN the original design of the side frame member (Fig. 3), service replacement of babbitt bearings for cross shafts required extensive disassembly of the machine. With the welded design (Fig. 4), however, it is now possible to utilize self-aligning roller bearings held in retainers that are simply bolted to the side frame member. All servicing can be done on the job with minimum down time.

The present welded design also affords other important benefits in manufacture. 49% less metal is needed. What little machining is necessary is done on light, fast machine tools. Shop assembly is simpler and can be done with fewer man-hours.

The shop cost of the welded steel frame is 21% less than that of the original construction.

Fig. 4—Present welded steel design. *Side members are formed from sheet steel. Individual retainers for self-aligning bearings are held to sides with three bolts. Photos courtesy The Fox River Tractor Company, Appleton, Wisconsin.*

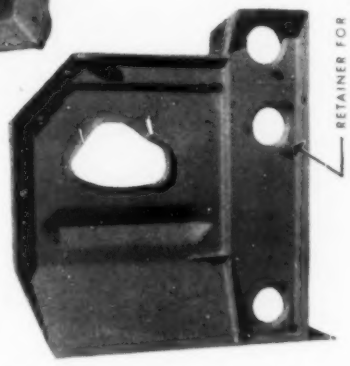


Fig. 3—Original construction *of side frame member weighed 47 pounds and required larger machine tools for boring the retainers for babbitt bearings.*

PROPER DESIGN IN WELDED STEEL ALWAYS IMPROVES PRODUCT AND LOWERS COST

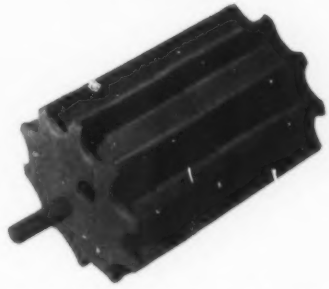


Fig. 1—Original design *of machine feeder roll required 63 pounds of iron.*

STRONGER, MORE RUGGED

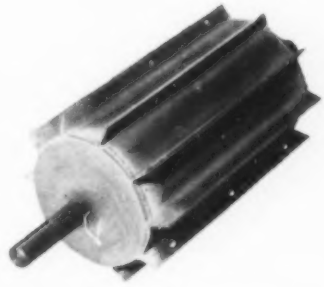


Fig. 2—Weldesign in steel takes 55% less material. *Costs 45% less to build. Eliminates former breakage in service.*

HERE'S MORE PROOF

Machine Design Sheets are available to designers and engineers. Simply write on your letterhead to Dept. 32.

THE LINCOLN ELECTRIC COMPANY
CLEVELAND 17, OHIO

Magnetic Starter for Reversing Motors

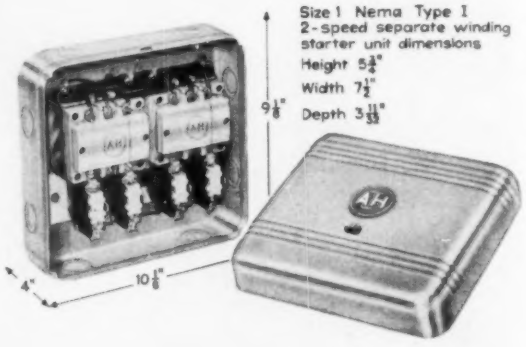
Designated types RAR and RAS, two new developed motor starters extend the scope of the RA magnetic starter, also made by this company, to include reversing and multi-speed motors. The RAR (Reversing) and RAS (Multi-speed) feature the right angle operating mechanism. Among other advantages claimed for this advanced design are: greatly reduced size and weight with increased operating efficiency, simplified straight-thru front wiring and more complete protection of electromotive equipment.

The multi-speed starters type RAS are available in separate winding type rated 110 to 550 v, 2 and 3 phase, 3 and 4 pole in sizes 0, 1, 2, 3, and 4. Also furnished in reconnected winding type rated 110 to 550 v, 3 phase, 3 and 5 pole in sizes 0, 1, 2, and 3.

To be certain that a motor is started at low speed before any faster speeds are demanded, a compelling relay is used. The operator, therefore, is required to push the slow button first and then press the high speed button in order to operate at high speed.

Controls equipped with sequence relays provide means of automatic acceleration with adjustable time delay between each step. To start the motor or change to a higher speed with the multi-speed starters, the desired speed button is pressed and the speed windings are automatically and progressively energized from low to the higher speed.

To prevent immediate change from a high speed to stop, a decelerating relay provides a definite time interval



in the low speed before stop in order to allow the inertia in a machine to dissipate. This permits stepping down motor speed to reduce a potential fatigue failure in safeguarding performance and life of the equipment.

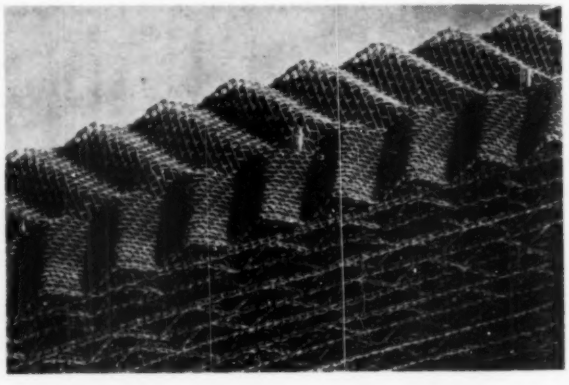
NEMA type I, steel housing, are available for all around indoor use. Type IV weatherproof enclosures are splashproof and are recommended for outdoor use. The type VII and IX are explosionproof housings.

Arrow-Hart & Hegeman Electric Co., 103 Hawthorn St., Hartford 6, Conn

Air Filter Operates At High Velocities

A high velocity air filter, the airsan viro-crimp, will operate at face velocities of 300 to 500 fpm at minimum resistance and high efficiency. The filter core is viscous type, and constructed of horizontal layers of galvanized wire mesh arranged to assure a large filter area with no appreciable pressure drop. The filter is arranged to have no direct opening in the media, thus assuring peak efficiency, large dust holding capacity and uniform loading. Because of the viro-crimp feature, the air flows into divided channels being baffled by a filter wall. There is no specific velocity (within the range of 300-500 fpm) at which it must operate for maximum efficiency.

An important safety feature is the hemmed edges of the filter, a feature that provides a smooth surface and allows easy handling for servicing. The filters are easily cleaned. Drain slots are used to increase drying speed and aid in cleaning. The air filters are of all metal construction.



Air Filter Corp., 108 N. Water St., Milwaukee 2, Wis.

KLING-OIL, a general purpose machinery oil having good metal adhesiveness, is tacky and clings to the moving parts of machinery. Because the oil stays longer than conventional oils, it is said to reduce the number of oilings required, sometimes by as much as five times. No gumming or build-up will result after continued use of the oil. The oil has a SAE-30 viscosity. Magnus Chemical Co., Inc., Garwood, N. J.

A LINE OF RUBBER-LINED BUTTERFLY VALVES for operation and tight shut-off at high pressures range in size from 4 in. to 36 in. and larger. The purpose of such rubber liners is to insure tight closure. The valve, body, and blade are of cast iron or cast steel with a steel blade. W. S. Rockwell Co., Fairfield, Conn.

CONTINUED ON PAGE 228

N-A-X AC9115 ALLOY STEEL offers a means of reducing the use of critical alloy steels of the "stainless" type in gas turbine and similar applications. In specific cases it has replaced over half the amount of strategic material originally required, with no sacrifice of quality.

N-A-X AC9115 ALLOY STEEL has high strength and toughness values at temperatures ranging from −70° F. to +1,000° F. It can be readily cold formed into the most difficult shapes; its response to welding by any process is excellent. It must, however, be suitably coated for protection against cold or hot corrosion.

Investigate the outstanding properties and characteristics of N-A-X AC9115 ALLOY STEEL and, through its use, conserve the critical material so necessary to our nation.

GREAT LAKES STEEL CORPORATION

N-A-X Alloy Division • Ecorse, Detroit 29, Michigan

NATIONAL STEEL CORPORATION

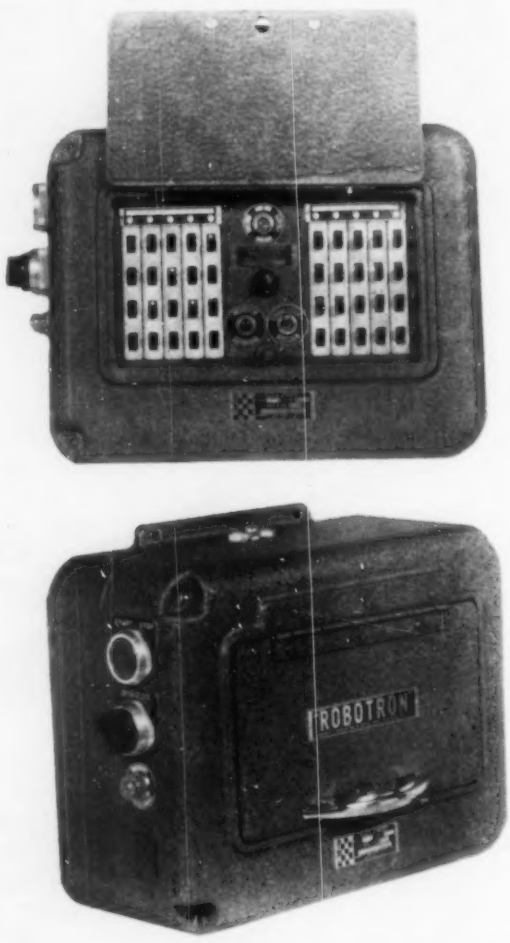
Unit Has Fine Control And Accurate Timing

The type E304 Robotron control box operates a hydraulic press, will bump or breath the press, and control the length of cure time. From zero to 19 bumps can be obtained and variably spaced by the selection of pushbuttons on the left side of the cycle set-up panel. The pushbuttons on the right of this panel determine the overall cure time. A range selector switch permits a choice of three time values for each pushbutton so that the controller has three consecutive time ranges such that the maximum cure time is 8 times the minimum cure time. For example: with a $\frac{1}{4}$ min value for each pushbutton, cures from 5 to 10 mins are obtained. Moving the range switch to number 2 position will give $\frac{1}{2}$ min time values to each pushbutton and permit a cure time from 10 to 20 minutes. With the range switch in the number 4 position time values of 1 min per pushbutton are obtained and the overall time is now 20 to 40 minutes. By using other rpm motors, faster or slower ranges may be obtained, and the motor timer unit is a plug-in element, changeable in the field in a few minutes. A protective fuse appears in the center of the panel together with a reset pushbutton. The hand automatic switch cuts out the operator's manual control unless thrown to the hand position.

As the control is electric, a solenoid valve is also built in the unit. A built-in pressure switch is also included so that when it is time to bump the press, the air in the diaphragm top of the pressure valve is exhausted, and as this diaphragm air pressure drops to about 3 psi, the valve is reversed, closing the press. The amount of water exhausted from the press determines the amount of bump opening and this is controllable by adjusting the pressure switch. An advantage of this method of bump control is that a mold change to a different thickness mold has no effect on the bump opening.

The robotron has essentially only two moving parts in the control section and there are no cams, gears or adjustments. Control is affected through timing by a synchronous motor with telephone type selector switches and a heavy duty power relay on the output circuit. The manufacturers claim the control to be rugged and dependable.

Emmett Machine & Mfg., Inc., 2249 14th St., Akron 14, Ohio



New Series of Heatsealing Polyamide Resins

A new series of compounds in the heatsealing polyamide resin line may be used alone or as modifiers for other resinous products. These new products are code named Polyamide Resin 90, 90S, 93S, 94S, 95S, and 100S.

Resin 90 is a hard, brittle resin made by the copolymerization of di-and tri-linoleic acid and other acids with ethylene diamine. It is resistant to greases, oils, water, alkalies, mild acids, organic solvents, and has a melting point of 185 C. It also serves as a coating for electrical units, and may be used as a molding compound and binder.

Adding a small amount of antioxidant to resin 90, produces the stabilized products known as 90S, 93S, 94S, and 95S. At high temperatures these resins have a gel time approximately 3 times longer than the standard polyamides. Because of their heat resistance, the resins are recommended for use in hot melt applications.

Polyamide resin 100 S, is a soft, tacky, plasticizing type of resin. It is made by the condensation of dimerized and trimerized unsaturated vegetable oil fatty acids with diethylene triamine. It is said to have good adhesive properties, particularly for non-porous surfaces, also adheres well to metals, glass, cellophanes, paper, rubber and leather. Because it is compatible with a wide range of materials, it is a potential plasticizer for resinous products. Mixtures of polyamide resin 100 with resins 93, 94, or 95 form very flexible, grease, solvent and water resistance coatings.

General Mills Research Lab., 2010 E. Hennepin Ave., Minneapolis 13, Minn.

CONTINUED ON PAGE 230

Hardinge Lathe uses a BODINE MOTOR

An infinitely variable carriage and cross slide feed is an exclusive feature of the new Model HLV Hardinge Lathe. The very nature and design of the carriage required that it be equipped with a motor that is compact, powerful and attractive in appearance. Specifications called for an instantly changeable power feed range of ¼" to 7" or, in other words, a speed ratio of 28 to 1. The torque over this wide speed range had to be uniform.

Bodine's wide variety of types and HP ratings permitted Hardinge Engineers to select an economical (as compared to a special type) standard motor capable of filling their rigid requirements. The smooth, attractive black japan finish and streamlined, totally enclosed frame of the Bodine Type NSH-34 shunt wound motor selected eliminated the necessity of covering or repainting the drive unit.

Whenever possible, it is economically advisable to select a standard motor for your application. Over 3500 standard Bodine motors—the widest variety of types and ratings (1/2000 to 1/6 HP) in the fractional horsepower motor field—simplifies this task. And when special motors are necessary, the wide selection of standard types available tends to keep the number of modifications to a minimum. If you have a motor application problem, it will pay you to consult Bodine engineers.

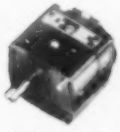
REASONS WHY

"Our engineering department has found your motors to be of top quality. In their original design work, you offered a sufficient number of types and sizes of motors to give our designers flexibility in their work. As you can see, we needed a compact, powerful motor to give smooth operation of our carriage."

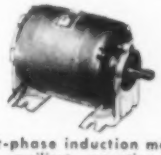
Hardinge Brothers, Inc.
Elmira, N. Y.

Over 3500 Standard Bodine Motors (1/2000 to 1/6 hp)

Series wound motor for adding machines, check protectors, motion picture projectors and similar applications.

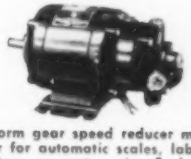


Built-in spur gear speed reducer motor. Especially designed for instruments and control apparatus.



Split-phase induction motor with resilient mounting for office machines, coin handling machines and similar products.

Offered in a variety of types for hand driers, communication equipment, bag closing machines and similar devices.



Worm gear speed reducer motor for automatic scales, laboratory apparatus, sign flashers and similar applications.

THE POWER BEHIND THE LEADING PRODUCTS

Bodine Electric Co., 2260 W. Ohio St., Chicago 12, Ill.

DISTRICT AGENTS

BUFFALO 3, N. Y.
Ellicott Square—S. E. Shea

CAMBRIDGE 39, MASS.
686 Massachusetts Ave.—W. A. Black

CLEVELAND 3, OHIO
4300 Euclid Ave.—W. R. Uffelman

DETROIT 1, MICHIGAN
4464 Cass Ave.—C. D. Miller

KANSAS CITY 6, MISSOURI
903 McGee Street—T. Pellmounter

LOS ANGELES 13, CALIF.
411 So. Wall St.—H. M. Hall

MINNEAPOLIS 13, MINNESOTA
712 Sixth Ave., So.—A. C. Jacobson

NEW YORK 18, N. Y.
55 West 42nd St.—H. C. Mayorga

ROCHESTER 4, N. Y.
825 Commerce Bldg.—S. E. Shea

SAN FRANCISCO 3, CALIF.
995 Market St.—J. F. Cady

Slip Ring Motor Has Flat End Bells

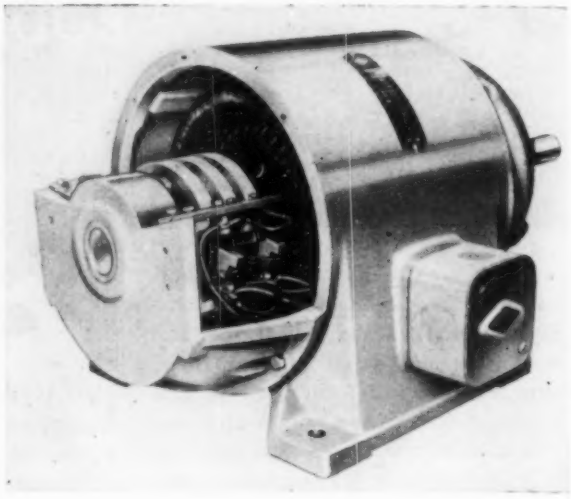
Having wide usage on cranes, fans, printing presses, and crushers, this new slip ring motor has variable speed, and high starting torque, on low starting current.

The unit features a new arrangement of the collector rings and brush assembly which permits complete housing in the motor's regular end bell. This new development eliminates the traditional protrusion of the assembly and reduces the overall length by about 6 in. and cuts down on other dimensions of standard squirrel cage motors. Protection against arcing and flashing is also offered.

In addition to these features, flat end bells are used, allowing brakes and other equipment to be attached on either end using face or flange type mountings, and permitting units to be mounted in any position.

Other features include: shorter bearing-to-bearing spacing, providing greater shaft rigidity; wound rotor construction immersed in varnish and baked to a rigid mass for maximum vibration resistance.

The slip ring motors are available separately in ratings from ¾ hp to 15 hp or, in conjunction with gear reducers made by this company, in ratings from ¾ hp. to 5 hp. Large openings are for access to collector rings and brushes.



Reuland Electric Co., Alhambra, Calif.

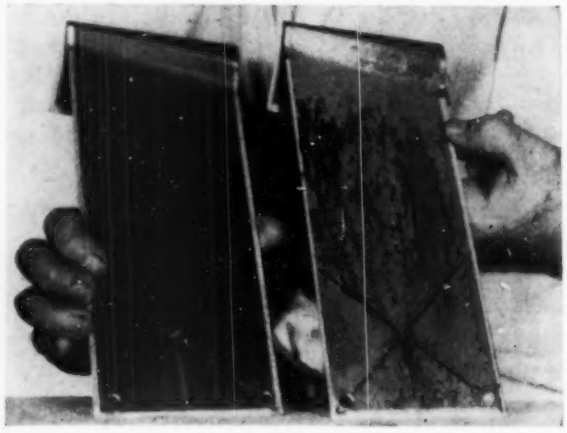
Alkyd Resin is Fast-Drying and Rust-Proof

Painting and priming of industrial and consumer goods can be speeded by a new Glyptal alkyd resin which air dries dust-free in five to ten minutes, and tack-free in three to four hours. Recommended applications include appliance and furniture finishes, primers, automotive and metal cabinet finishes, and venetial blind enamels.

Designated as glyptal 7422, the new paint resin is a short, pure, oil-modified alkyd, free of resin, phenolic, styrene, or other modifiers. The resin is recommended for industrial finishes requiring fast air-dry or very rapid bake. It has good color retention, adhesion, toughness, mar resistance, and solt spray resistance.

In the illustration, the panel on the right, coated with a conventional primer, is rusted and corroded. The panel on the left is coated with the glyptal alkyd resin and is untouched. The test was the ASTM standard salt spray test of a 20 percent salt solution run at 95 F for 300 hours.

Unlike conventional short-oil alkyds, glyptal 7422 has a high tolerance for aliphatic thinners, may be safely thinned with proportions as high as 200 percent naptha and petroleum spirits without danger of precipitation or instability. Also, tests show that for baking enamels, amine resin requirements can be reduced 30 percent to 50 percent without lowering hardness below that of conventional baking alkyds. Finishes formulated with 7422 can be made to perform like styrenated alkyds without tacking, and poor solvent and mar resistance.



General Electric Co., Pittsfield, Mass.

A NEW LINE OF SEALING COMPOUNDS for use where high electrical insulation and low moisture transmission are required, has been found to be useful for the sealing and casting of electronic parts, batteries, transformers, coils, condensers and other types of electrical parts. H. V. Hardman Co., Inc., 571 Cortlandt St., Belleville, N. J.

MOULDED POWDERED-IRON TOROIDS are now being produced in a size range extending from 0.800 to 3.375 in. outside diameters. Made in magnetic materials for high inductance, and low generation of harmonic distortion products. Lenkurt Electric Co., 1122 County Rd., San Carlos, Calif.

CONTINUED ON PAGE 232

New MEAD INDUSTRIAL AIR POWER CATALOG ready—

Full of suggestions FOR FASTER, CHEAPER PRODUCTION

New MEAD AIR POWER CATALOG illustrates, describes the complete line of famous MEAD-DESIGNED Air Operated Devices which have been speeding work, saving time and money for America's most "Cost Conscious" plants! Get your copy.

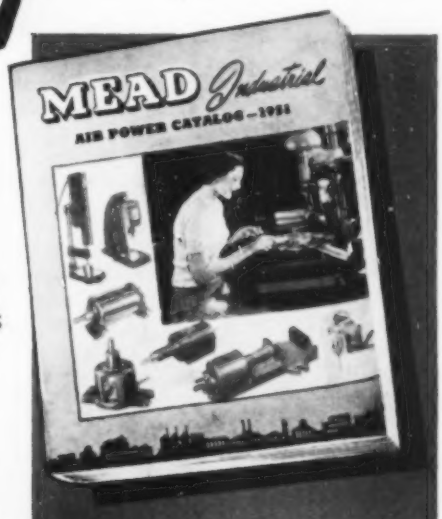
IT PICTURES THESE AIR-OPERATED DEVICES

Air Presses · Rotary Work Feeders · Air Vises · Drill Press Feeds · Impact Hammers

Midget Air-Clamps* · Single Acting Air-Clamps* · Double Acting Air-Clamps*

***AIR CYLINDERS**

Air Valves · Meadmatic Timers · Other Work Feeders · Air Collet Fixtures · Air Power Set Ups



Tear out memo coupon— to remind you —or better yet mail coupon now!

*Originators of the famous Air-Clamp**

and **MEAD AIR OPERATED DEVICES**

MEAD SPECIALTIES COMPANY
4114 North Knox Ave., Dept. 0000
Chicago 41, Illinois

Memo Coupon

MEAD SPECIALTIES CO.
4114 N. Knox Ave., DEPT PE-22, Chicago 41, Illinois

Send free copy of new, colored MEAD INDUSTRIAL AIR POWER CATALOG describing the complete line of famous Mead air-operated devices.

Name_____

Company_____

Address_____

City_____ Zone____ State_____

Controller With One Knob Adjustment

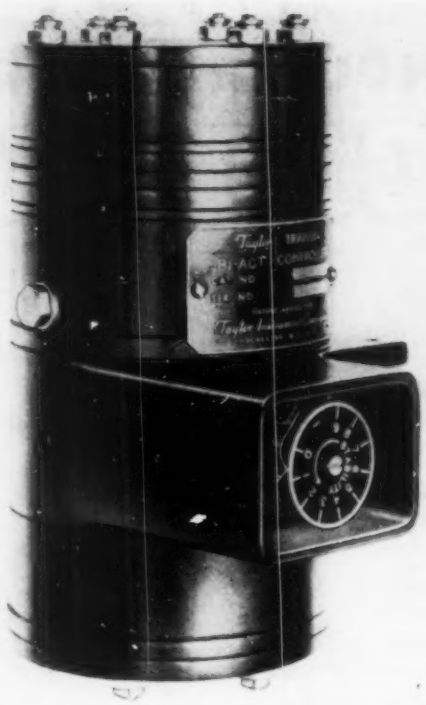
The transet bi-act controller, a non-indicating, force-balancing controller with only one-knob adjustment for two control responses is designed for applications where it is desirable to transmit the measured variable to some remote location.

It is adaptable to flow, liquid level, or pressure applications requiring fast reset rates and broad throttling bands, or applications where derivative action is not essential. This controller is another component part of a three-part control system made by this company which includes the controller, transmitters, and the miniature recorder for graphic panel installations.

The controller features: (1) a simplified control circuit which pneumatically links proportional and automatic reset responses together; (2) one-knob to adjust both proportional and automatic reset responses so that the processes can be brought to a stable condition easier; (3) controller action that can be changed quickly without disturbing any piping connections; (4) an optional, plug-in type, leakless manifold which gives a simple means for connecting or removing the controller; (5) rapid controller action that is obtained by a large capacity booster air relay; (6) built in cut-off relay so that the controllers may be either panel or field mounted.

The controller, which has a wide variety of applications, measures 7½ in. overall length and has a range of adjustment of 1 to 200 percent throttling rang and automatic reset of 0 to 10 repeats per minute. It is available with or without the manifold bracket.

Taylor Instrument Companies, Rochester 1, N. Y.



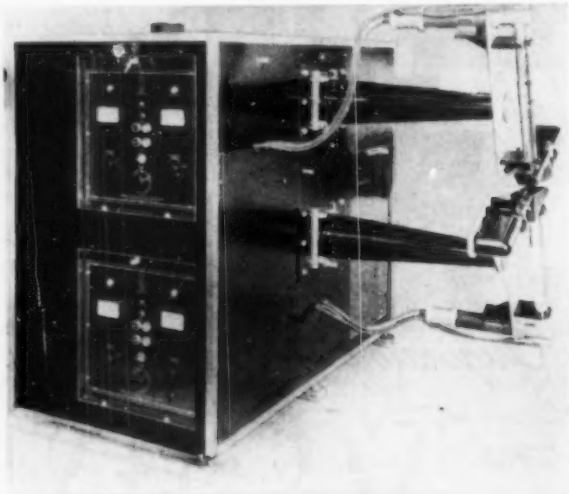
Gage Checks Thickness of Tin Plate

Using a non-destructive method for checking the thickness of tin-plate, the design of this new thickness gage utilizes an X-ray beam which is directed upon the surface of the sheet under test. Through proper kilovoltage control of the beam, the tin planting is penetrated, the beam striking the steel under it. Rays emitted by the iron are measured by means of Geiger counters and the intensity can be expressed as a logarithmic function of tin plate thickness. In practice this is reduced to a reading on a printing register.

In the optical system, the X-ray tube is mounted so the beam is defined by a slit and two apertures, and makes an angle of 70 deg with the horizontal. This arrangement projects radiation onto the tin plate in an eccentric circular area, measuring approximately 2¼ in. diameter.

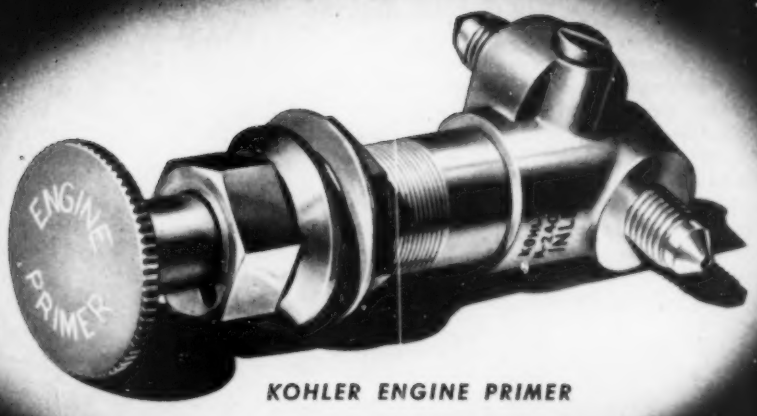
Two Geiger counter tubes are mounted on the same side of the tin plate as the X-ray tube at a fixed angle with the horizontal. These tubes detect and measure intensity of the radiation coming out after it has passed through a collimating system which restricts to a given range the absorption path in the tin.

The thickness gage is 7½ ft long, 6½ ft wide, and 5 ft high. It is rated 6 kva and will handle tin coatings which range in thickness from 0 to 150 micro-inches. It is available as a single unit or as a double unit, to measure tin plate thickness on one or both sides of a steel plate.



North American Philips Co., Inc., 750 S. Fulton Ave., Mt. Vernon, N. Y.

CONTINUED ON PAGE 234



KOHLER ENGINE PRIMER

KOHLER PRECISION CONTROLS

Hydraulic · Fuel · Pneumatic

The Kohler Engine Primer will operate efficiently at low temperatures, using Diesel oil, gasoline, or ether, to start internal combustion engines.

Kohler Co. is a leading supplier of precision controls to manufacturers of Diesel engines, automobiles, trucks, tractors, jet engines, military, commercial and private aircraft, agricultural and industrial test equipment.

Our engineers develop, for volume production, valves and fittings suited to special applications. Write for illustrated catalog.

Kohler Co., Kohler, Wisconsin. Established 1873

KOHLER OF KOHLER

PLUMBING FIXTURES · HEATING EQUIPMENT · ELECTRIC PLANTS · AIR-COOLED ENGINES · PRECISION CONTROLS

Easy Opening Clamp For Wire Bundles

Security for bundles of wire in aircraft, heavy vehicles or mobile units is assured by a new wire harness clamp, which can be opened and closed without the use of tools, and is built with an interlocking slot and tongue so it cannot be opened accidentally. The T-shaped tongue, inserted by pressure of the hand on the clamp, slips into a narrow portion of the slot and is held by lateral and outward spring action.

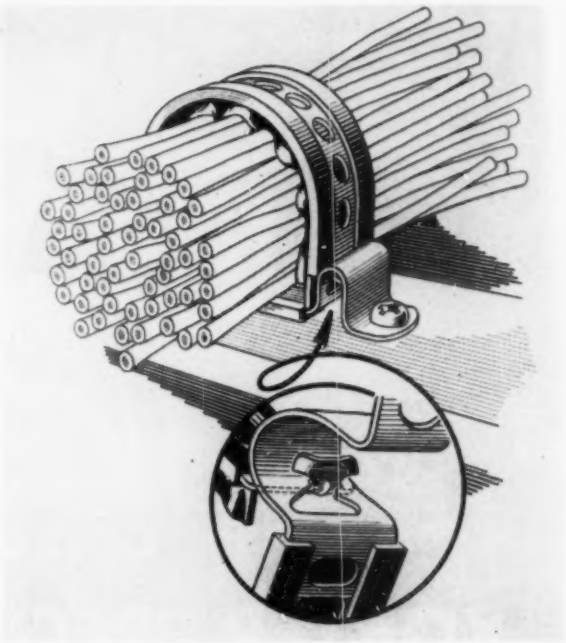
Made to be used singly or in tandem and to hold bundles $\frac{5}{16}$ in. to $1\frac{1}{4}$ in. in dia, this clamp meets maximum loading requirements for size as set forth by the electrical groups in military aircraft.

The clamp offers the following additional features:

1. It can be opened without removal from the structure to which it is attached;
2. It can be preassembled to the wire bundle to facilitate installation of the completed harness to the aircraft or other structure;
3. It is suitable for wire bundles which have varying dimensions caused by variations in the thickness of wire insulation.
4. It is suitable for mounting to the structure by simple hand operation with a screw driver.

Additional information on these clamps may be obtained by writing to the manufacturer.

Tinnerman Products, Inc., Box 6688, Cleveland, Ohio

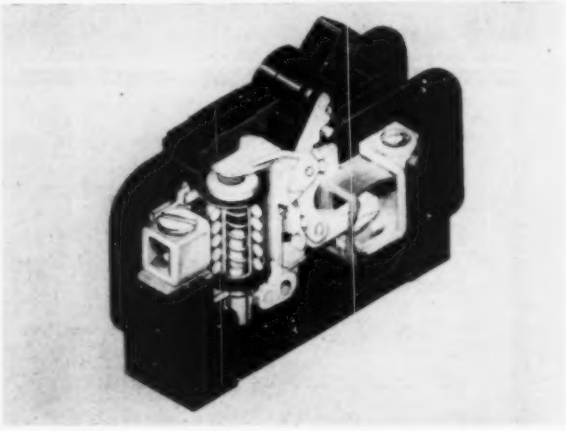


Interchangeable Magnetic Circuit Breakers

Arc extinction in the new Magnette circuit breaker is provided by a quenching well, which gives a large contact area and many arcing points that guard against pitting. Heat from any arc causes pressure in the well which then quenches the arc to extinction. Tripping of the breaker is affected only by the current itself. On simple overloads, the breaker has a time delay; but at ten times the rated current or short circuit conditions it trips instantly.

Principle application of the new breaker is in panelboards handling lighting and appliance circuits, and as a built-in combination start-stop switch and overload protector for electrical equipment. The breaker is available in single pole units, 120 v a-c, 15 to 60 amps; or two pole units, 120/240 v a-c, 15 to 35 amps, approved by Underwriters' Laboratories. As it has no thermal elements. Its rating is not affected by room or panelboad temperature.

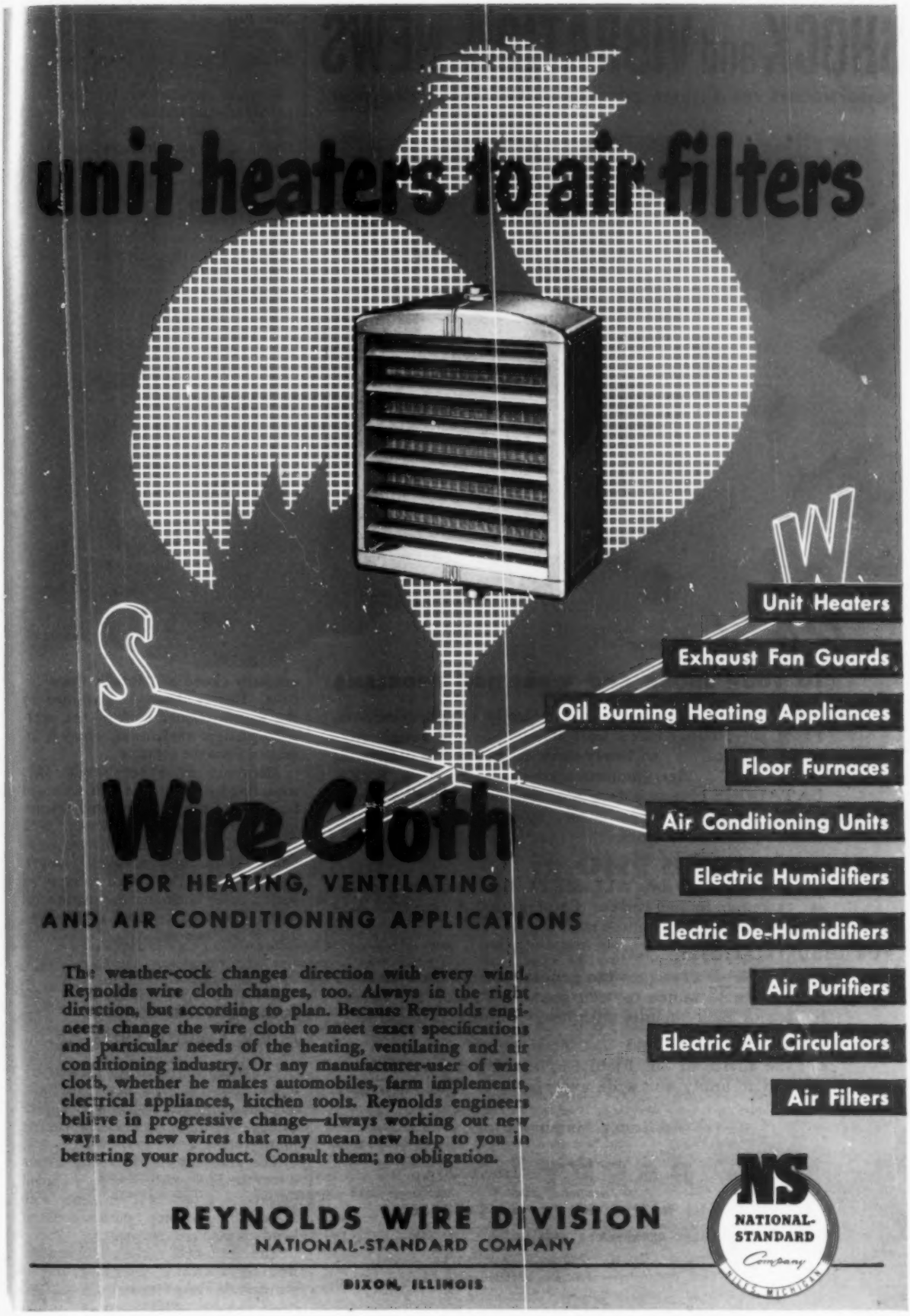
Heinemann Elec. Co., 308 Plum St., Trenton 2, N. J.



AN IMPROVED PRESSURE-SENSITIVE-TYPE PAPER MASK enables fast, accurate masking for production-line spray or brush painting and sandblasting. The manufacturer claims as much as 90 percent reduction in man-hours through use of the custom die-cut mask. Overmasking down the sides or over the surface is eliminated, as every mask exactly fits the area to be protected. A pressure-sensitive adhesive is impregnated on the back of paint and lacquer resistant masking paper. Special heat resisting paper for bake ovens is available. By-Buk Co., 4314 W. Pico Blvd., Los Angeles 19, Calif.

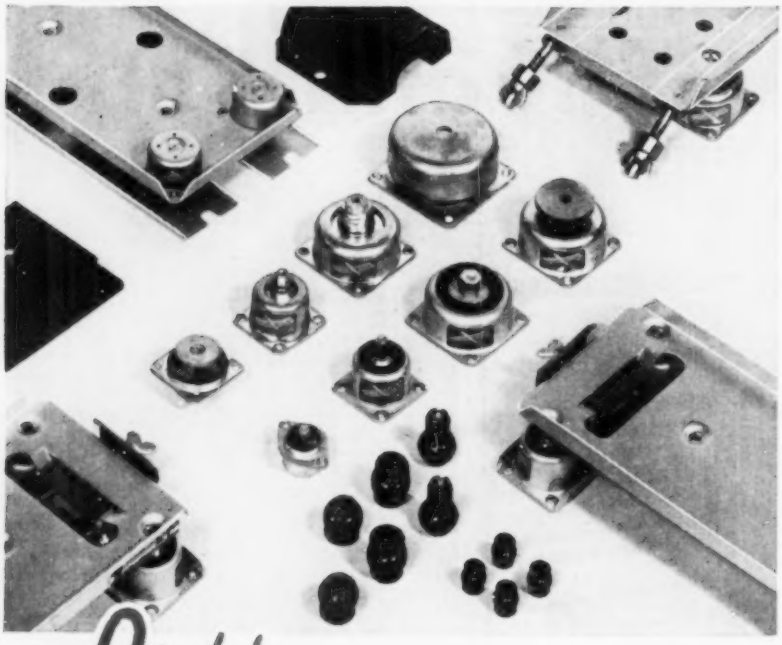
VALVE SEATS machined from FM-10001 nylon rod are said to have an estimated life of from 15 to 20 years with improved seating. These seats may be used in oxygen, hydrogen, and helium regulators, as well as for high pressure aircraft check valves. The Polymer Corp., Reading, Pa.

CONTINUED ON PAGE 236


unit heaters to air filters
Unit Heaters
Exhaust Fan Guards
Oil Burning Heating Appliances
Floor Furnaces
Air Conditioning Units
Electric Humidifiers
Electric De-Humidifiers
Air Purifiers
Electric Air Circulators
Air Filters
Wire Cloth
FOR HEATING, VENTILATING
AND AIR CONDITIONING APPLICATIONS
The weather-cock changes direction with every wind. Reynolds wire cloth changes, too. Always in the right direction, but according to plan. Because Reynolds engineers change the wire cloth to meet exact specifications and particular needs of the heating, ventilating and air conditioning industry. Or any manufacturer-user of wire cloth, whether he makes automobiles, farm implements, electrical appliances, kitchen tools. Reynolds engineers believe in progressive change—always working out new ways and new wires that may mean new help to you in bettering your product. Consult them; no obligation.
REYNOLDS WIRE DIVISION
NATIONAL-STANDARD COMPANY
DIXON, ILLINOIS
NS
NATIONAL-STANDARD
Company
NILES, MICHIGAN

SHOCK and VIBRATION NEWS

BARRYMOUNTS FOR ASSURED CONTROL OF SHOCK AND VIBRATION



the Right answer

TO YOUR SHOCK AND VIBRATION PROBLEMS

will be found in this complete family of Barrymounts. From tiny, ounce-rated unit mounts . . . through ruggedized bases . . . to heavy-duty isolators for industrial machinery . . . Barrymounts meet all your needs. FREE CATALOGS give you details of dimensions, load ratings, and military specifications met by these effective vibration and shock isolators.

FOR AIRCRAFT SERVICE

Catalog 509 describes ALL-METL Barrymounts for use at extreme temperatures. Catalog 502-A covers Air-damped unit mounts and bases.

FOR INDUSTRIAL USES

Catalog 504-B describes the general line of Barrymounts rated from 1/8 ounce to 3300 pounds. Catalog 607 covers the use of Barrymounts with heavy industrial machinery.

And for SPECIAL PROBLEMS

ask the advice of our Field Engineering department, organized to apply our wide experience to your particular needs.

Address all inquiries to:

THE **BARRY** CORP.

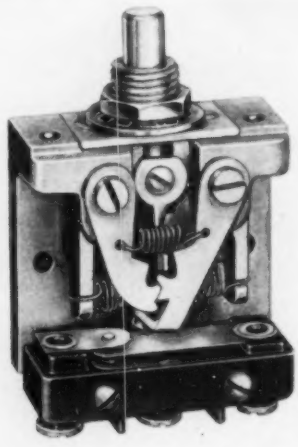
730 PLEASANT ST., WATERTOWN 72, MASSACHUSETTS

SALES REPRESENTATIVES IN

Atlanta Chicago Cleveland Dallas Dayton Detroit Los Angeles
Minneapolis New York Philadelphia Phoenix Rochester St. Louis
San Francisco Seattle Toronto Washington

Many Uses For New Switch

Typical applications for this alternate-contact-operating switch are on machine tools; circuit transfer of timers and recording equipment; in safety circuits; and as a limit switch. The operation is such that the first press transfers the contacts—and the second press restores them. Single-pole, double-throw contacts permit adaption of this switch to either



normally closed or normally open circuits. Fast switching is permitted by the return-action design of the operating plunger mechanism, which is insulated from the contacts.

Mounting is either single hole mounting by means of a $\frac{1}{2}$ in. threaded bushing, or top or side panel mounting with clearance holes for 6-32 screws. Overall dimensions are 2 in. wide, $2\frac{5}{32}$ in. high including plunger, $1\frac{3}{32}$ in. deep. The switch is supplied with a cover enclosing the mechanical parts. Contacts are rated at 20 amps, 125 v a-c, non-inductive.

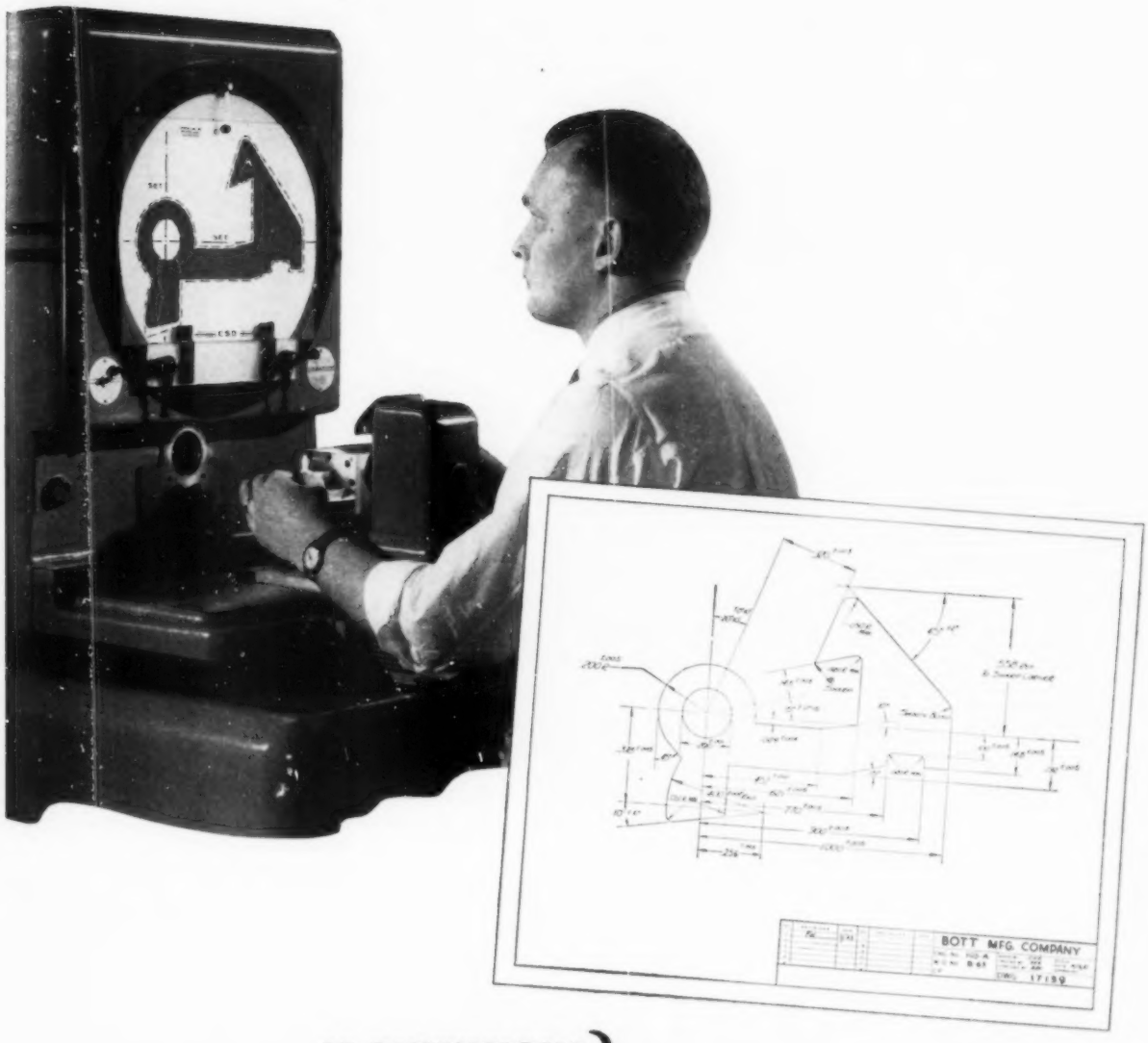
General Control Co., Boston 34, Mass.

Raintight Outdoor Motor Control Units

Originally designed for use on irrigation projects, this new rain-tight, outdoor motor control unit is applicable to other outdoor motor control jobs.

The units consist of a combination across-the-line starter with a circuit breaker in a rain-tight enclosure with a built-in start-stop pushbutton, or hand-off auto selector switch.

The sheet steel enclosure is bonderized for corrosion resistance and is finished in gray enamel. A hinged cover can be swung open or latched



He checks 15 DIMENSIONS 8 RADII 7 ANGLES } in ONE operation

To check this part completely and accurately by usual methods, you might need as many as two dozen or more different gages—and you still wouldn't be sure all corners were sharp, all angles and radii exact. There's a much faster, more accurate way to do the job completely, one that requires no mechanical gages that can lose accuracy through wear.

On the Kodak Contour Projector, Model 3, you just slip the part into a holding fixture and compare its magnified image with a "chart-gage" over the bright screen. *Every* detail shown on the drawing is quickly and directly compared against the part itself, to close tolerances and in *one* operation. Little training or experience is required.

The part we show here is a relatively simple one for an optical comparator. With proper fixtures, charts, and accessories, you can measure all sorts of complex parts, large or small. Changes in specifications generally require nothing more than a corresponding change on the chart.

So overwhelmingly has industry turned to optical gaging that production of the Kodak Contour Projector, Model 3, the outstanding instrument for this method, has been greatly accelerated. Deliveries are rapid, and the cost of projector, fixture, chart-gages, and accessories usually comes below corresponding sets of mechanical gages. To get an idea of the large labor savings that the Kodak Contour Projector can bring to your inspection problems, get in touch with Eastman Kodak Company, Industrial Optical Sales Division, Rochester 4, N. Y.

the KODAK CONTOUR PROJECTOR

If you want to check precision spur and helical gears in action, write for information about Kodak Conju-Gage Instrumentation.

Kodak
TRADE-MARK

simulate copper, brass and bronze on products like these with

M&W PLATELUSTRE

Don't let critical metals put a *needless* crimp in your production!

Take zinc or steel—apply a coating of one of the new PLATELUSTRE finishes. You wind up with products and parts that look so much like copper, brass and bronze that *the eye can scarcely tell the difference!*

Whether you have been using now unavailable copper and its alloys for *making* products or for *plating* products, you will find these new M & W finishes *equally* effective in keeping your plant running. There are types for air-drying and baking schedules — pick the one that best fits *your* production requirements.

Let an M & W Technical Service Engineer show you—*right in your own plant*—how easy these PLATELUSTRE coatings are to use, and what striking effects they produce. Or, if you prefer, write for free literature.

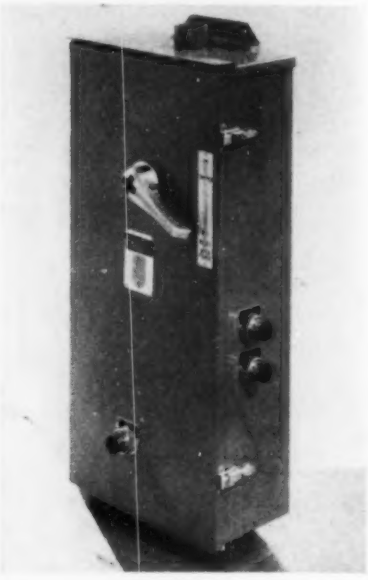
PIONEERS IN PROTECTION

76th YEAR

MAAS & WALDSTEIN CO. 438 RIVERSIDE AVE. NEWARK 4, N. J.

Midwest Div.: 1658 Carroll Ave., Chicago 12, Ill. • Pacific Coast Div.: Smith-Davis Co., 10751 Venice Blvd., Los Angeles 34, Cal.

MANUFACTURERS OF INDUSTRIAL FINISHES



and padlocked closed. A neoprene gasket around the edge of the cover and protective shield at the top of the enclosure prevent rain leakage. The pushbutton or selector switch, and the reset button also are rain-tight.

A self-indicating slamproof handle is provided for operation of the circuit breaker. This handle has separate positions for on, tripped, off, reset, and open cover, and can be padlocked in the off position by up to three separate padlocks.

The starter and breaker are mounted on a steel panel, permitting the removal of the complete interior as a unit for replacement or servicing. Mounting brackets at the top and bottom of the enclosure permit surface mounting, and a 1¼ in. threaded hub is provided at the top for conduit connections. There are knock-outs at the sides and bottom of the enclosure.

When required, one or two control relays, a third overload relay, or a control transformer can be supplied.

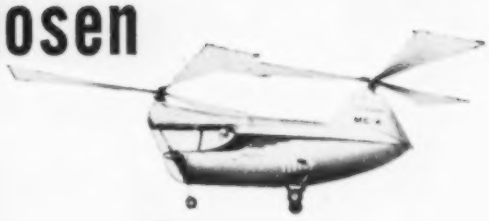
These starters, designated as class 11-206-NR, are available in NEMA sizes 1 through 5. Standard voltages are 220 v and 440 v, 60 cyc, although with proper coils the starters are suitable for voltages up to 600 volts.

Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa.

Carbon Soldered To Metal

A new process makes it as practical to solder carbon to metal as it is to solder metal to metal. By having this unwettable refractory material soldered directly to metal supports, it is possible to get all of the advantages of carbon

Gates V-Belts are chosen to keep HELICOPTERS aloft!



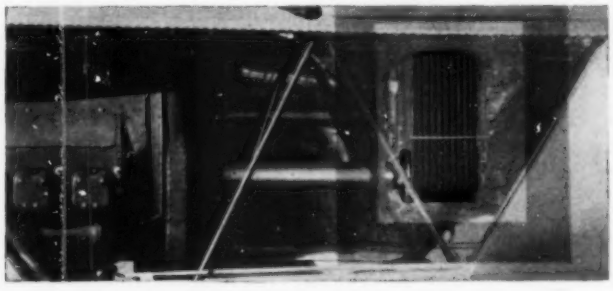
McCulloch Tandem-Rotor Helicopter

(Above) Two-place helicopter employs tandem-mounted, intermeshing rotors—a total of six rotor blades—powered by a 200-hp, six-cyl., aircooled horizontal engine installed at the rear. (Lower left) Gates-engineered V-BELTS, shown to rear of the engine, transmit power from the engine to the main drive shaft which in turn drives the reduction gearing for the rotors.

Because a helicopter is air-borne entirely by the turning of its rotors, McCulloch Engineers who designed this helicopter and supply it to the Navy had to be sure that the drive to the rotors was, above all, safe and reliable—a drive that would not fail when the helicopter was in the air.

The special difficulty in designing this drive was the extreme *compactness* required.

On small diameter pulleys and short center distances, the drive must handle 200 horsepower for 1000 hours at cruising speed and 500 hours at high speed. Ordinarily, it would have been impossible to achieve these results.



A Noteble Application of Gates SPECIALIZED Research

However, Gates had developed a V-Belt which in thousands of applications had proved to have the exact characteristics required for this helicopter drive—and Gates had also developed design data which showed at once the applicability of this belt.

It was not by accident, therefore, that Gates Engineers were at once prepared to supply a V-Belt capable of handling this most exacting assignment and —in close co-operation with McCulloch Engineers—they developed the drive shown which has most successfully met all requirements.

Gates readiness to meet successfully *any* V-Belt Drive assignment is possible because Gates runs an *average* of 32,000 hours of testing *every week* on V-Belts alone! (32,000 hours is equivalent to *five years* of life for one belt.)

And the real value to you of such exhaustive testing is this: Laboratory findings are carefully checked by tests made under actual field conditions and the *results* are at once reduced to *usable data* for the design of V-Belt Drives to *perform whatever task may be required!*

Phone for a Gates Field Engineer

If you have a difficult drive to design, or if some drive in your plant is giving trouble, or if you only want to be sure what size and construction of V-Belts will give the most efficient and the lowest cost service on any particular drive—you have only to phone a Gates Field Engineer, *always near you* in all industrial centers.

Just look in your phone book under "Gates Rubber." A Gates Field Engineer will come right to your plant and put at your service the full benefits of Gates V-Belt knowledge and experience *without the slightest obligation!*

ENG-522

Gates VULCO ROPE DRIVES

Engineering Offices and Jobber Stocks IN ALL INDUSTRIAL CENTERS of the U. S. and 71 Foreign Countries

THE GATES RUBBER COMPANY

DENVER, U. S. A.

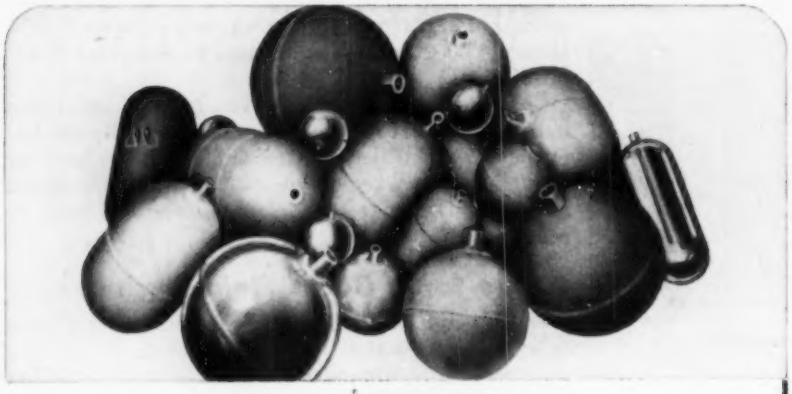
The World's Largest Makers of V-Belts

Orders for Sewall Stock Sprockets carry the assurance of complete interchangeability and satisfactory performance. Wide range of sizes. *Send for the Sewall Catalog.*

Prompt quotations on your requirements of special gears and sprockets.

By the Makers of Sewall Gears

E. B. SEWALL MANUFACTURING CO.
696 Glendale St. • St. Paul 4, Minnesota



Send for Nicholson

FLOAT BULLETIN 650

Complete Data on Welded Floats: Diagrams, Tables, Formulae for Calculating Buoyancies

The booklet is a standard reference for specifiers of welded floats. Nicholson furnishes any type for external or internal pressures; in stainless steel, Monel, chromium, cadmium or copper - plated steel. Sizes, 2" to 14" diam., press. to 4800 lbs.; standard or special connections. Quick delivery on many sizes and shapes. Nicholson floats are standard with hundreds of manufacturers.

W. H. NICHOLSON & CO.
TRAPS · VALVES · FLOATS
200 OREGON ST. WILKES-BARRE, PA.

for contacts, small brushes, friction devices and many other purposes. Fixtures necessary for bolting or clamping the carbon units in place are eliminated.

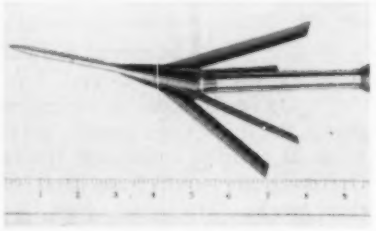
The new method permits welding carbon contacts directly to metal arms. Carbon brushes can be soldered to phosphor bronze or beryllium copper leaf springs eliminating brush holders and shunts.

Stackpole Carbon Co., St. Marys, Pa.

Aerohead Pickup Operates At Speeds Up to Mach. 3

The Ogive Pitch and Yaw Angle of attack pickup, which operates at subsonic and supersonic speeds up to Mach 3, has, in operation, the ogive and fin assembly swivel on a universal joint to face the airstream at all times.

Model 2519 D measures pitch and



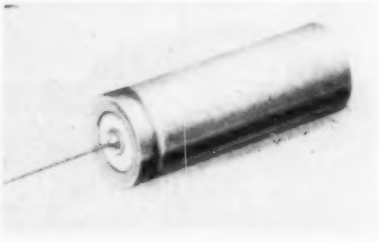
yaw angle of attack in ranges up to ±20 deg with an accuracy of 0.2 degree. The ogive is 2½ in. long. Model 25112 is identical with the addition of a pitot static tube mounted on the ogive. Features of both are high frequency, and high electrical potentiometric output of 0-5 v d-c.

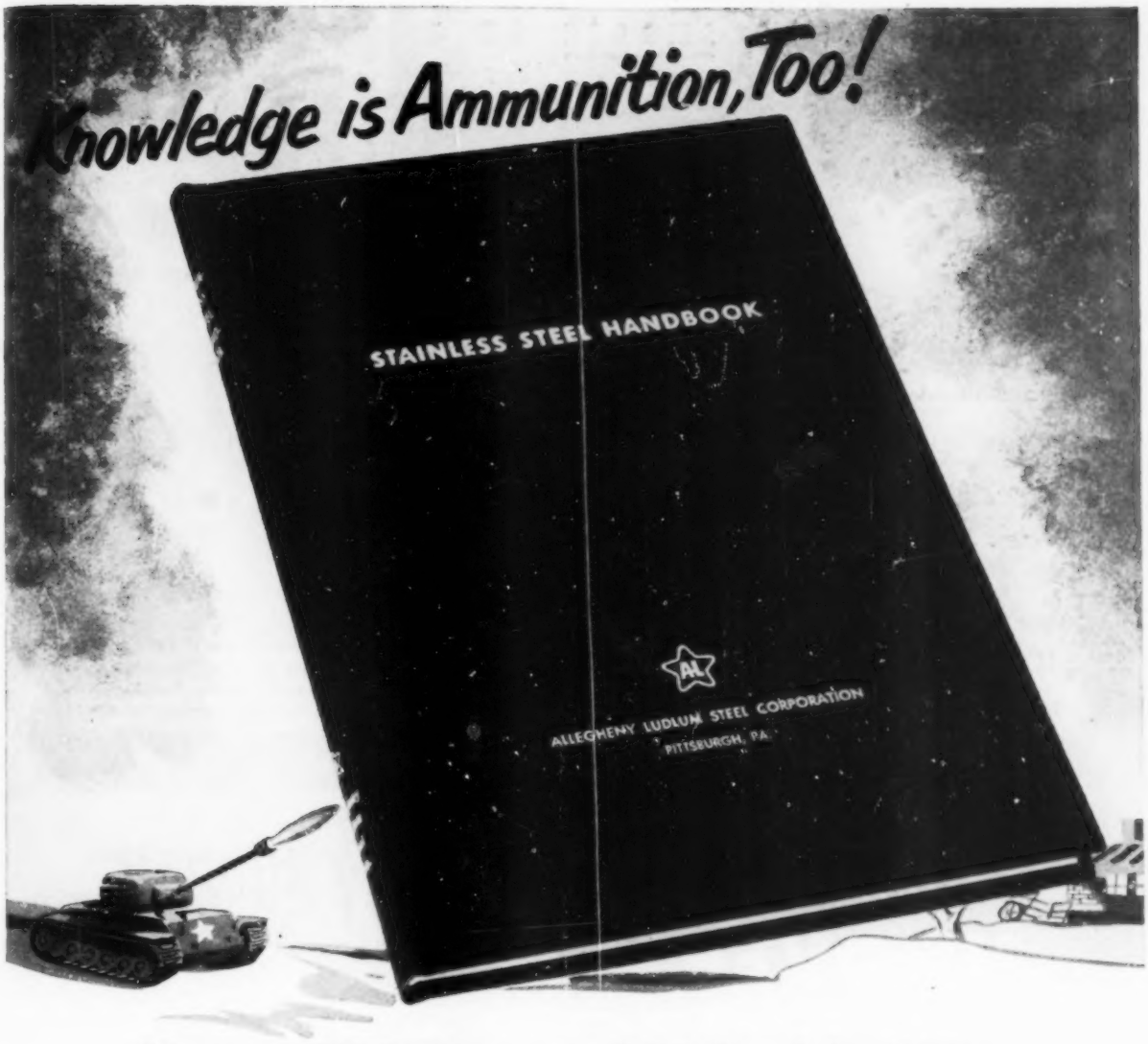
G. M. Giannini Co., Pasadena, Calif.

Vacuum Tight Capacitor Seals

New chemelec hermetic seals for capacitor can sizes from 0.377 in. to 0.962 in. are available for use where severe service conditions such as vibration, high and low temperatures, and thermal shock are to be encountered.

Utilizing a special method of producing a fused hermetic seal between





Here's 124 Pages of Valuable Data on STAINLESS STEEL

Stainless steel is a critical rearmament material. As the nation's mobilization program shifts into higher speed, supplies of this vital alloy are becoming increasingly restricted. If you're using stainless, be sure you make every pound go as far as possible.

Allegheny Ludlum's new 124-page, case-bound Stainless Steel Handbook is ready for distribution now. It will help you to select the right stainless steel and to use it right. Comprehensive listings of analysis, properties and characteristics of each type will guide you in specifying grades that will do your job most efficiently. Clear, concise fabrication data will help you speed production and cu. waste.

Your copy of the Stainless Steel Handbook will be sent—*without charge*—upon request. Our only stipulation: please make your request upon your company letterhead. ● Write Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pa.

ADDRESS DEPT. PE-26

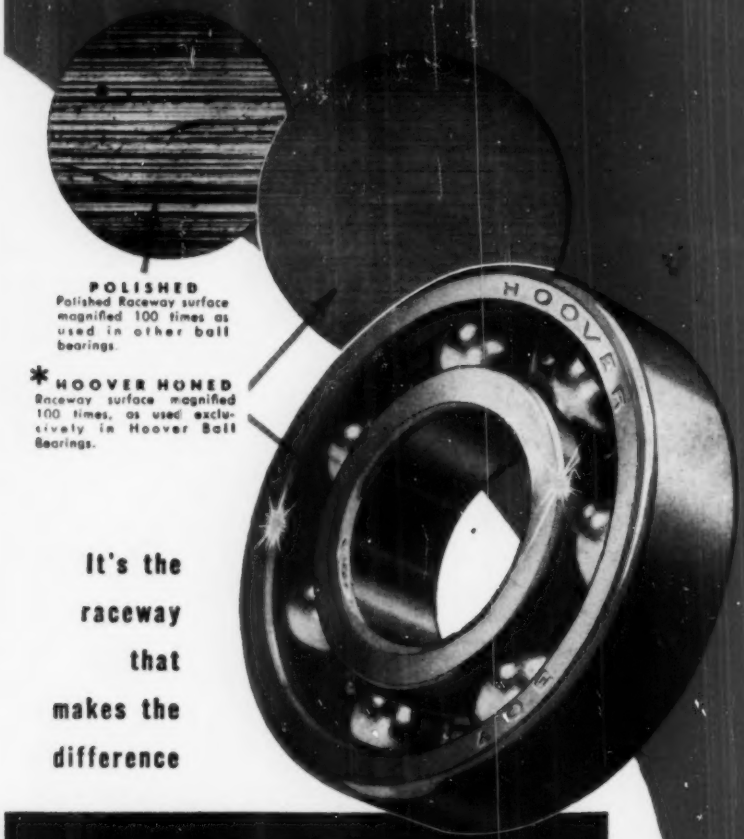
W&D 3947

Remember this also
America must have more Scrap to make more Steel!
Get in the Scrap Now!

You can make it **BETTER** with
Allegheny Metal

AL
TIME-TESTED STAINLESS STEEL

Nothing is as smooth as a
HOOVER HONED RACEWAY*


POLISHED
Polished Raceway surface magnified 100 times as used in other ball bearings.
*HOOVER HONED
Raceway surface magnified 100 times, as used exclusively in Hoover Ball Bearings.
HOOVER

It's the raceway that makes the difference

HOOVER
America's only
BALL BEARING
with Honed Raceways

90% longer life
30% greater load
Amazing Quietness

The Aristocrat of Bearings

HOOVER BALL AND BEARING CO.
ANN ARBOR, MICHIGAN

teflon, a tetrafluoroethylene resin, and metal, a metal surface is applied to the outer edge and center of the seal, ready for soldering to the capacitor can and solder-sealing the lead wire vacuum-tight. This design is said to simplify assembly, as it eliminates exhaust vents. The center eyelet accommodates the condenser wire with a loose fit to allow exhausting prior to sealing.

Because of the elasticity of the plastic and the nature of the fused seal, the capacitor seals have no acute strain point because of unequal rates of thermal expansion, as with glass-to-metal and ceramics-to-metal seals. Also, resiliency of the plastic permits them to withstand severe mechanical shock and vibration in service, and there is no danger of breakage in assembly.

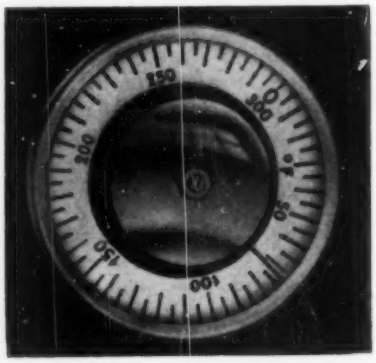
These seals will not d-c plate. They are serviceable at temperature from —110 F. to 500 F. without appreciable change in electrical characteristics. Because of zero water absorption, they are unaffected by humidity. They are non-flammable, impervious to corrosive atmospheres and fungus.

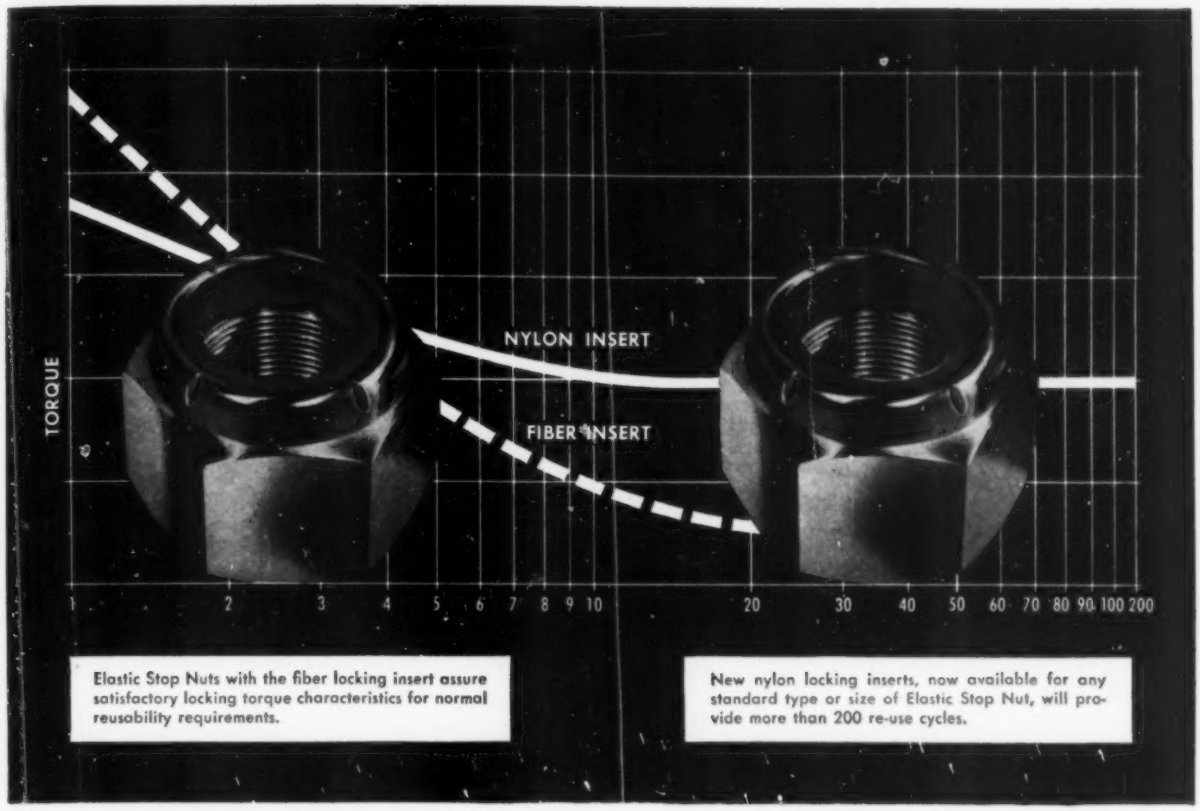
U. S. Gasket Co., Flurocarbon Products Div., Camden 1, N. J.

Surface Temperatures Accurately Checked

A new surface temperature thermometer, which may be easily attached to any flat surface by applying a small amount of silicone grease, accurately checks the outside temperature of pipes, plastic dies, rubber molds, and cylinder blocks. The instrument, which sticks on the surface being checked, is also used for getting the external temperatures of refrigerators, cold chambers, and freezers, to check for wall leakage; checking the temperatures of journals and other bearings, and electric motors; and for checking ceiling and floor temperatures.

The silicone grease, used for securing the thermometer in place, does not




TORQUE
NYLON INSERT
FIBER INSERT
1 2 3 4 5 6 7 8 9 10
20 30 40 50 60 70 80 90 100 200
Elastic Stop Nuts with the fiber locking insert assure satisfactory locking torque characteristics for normal reusability requirements.
New nylon locking inserts, now available for any standard type or size of Elastic Stop Nut, will provide more than 200 re-use cycles.

How do you measure Reusability?

UP TO FIFTEEN TIMES?

For assemblies that must be locked in place, Elastic Stop Nuts with fiber locking inserts guarantee a permanently secure grip—plus ample reusability to cover most normal maintenance requirements.

For assemblies that must be disassembled and reassembled five, eight, ten, or more times during normal use, fiber insert Elastic Stop Nuts make the ideal self-locking fastener.

When an Elastic Stop Nut is run on a bolt, the Red Elastic Collar hugs the bolt—actually makes a skin-tight fit against the entire contact length of the threads—and this controlled torque firmly resists vibration or shock. When the Elastic Stop Nut is removed from the bolt, the natural resiliency of the Red Elastic Collar is your guarantee of continuing torque when the nut is reapplied.

ESNA
TRADE MARK

MORE THAN FIFTEEN TIMES?

Now, for assemblies that require constant adjustment or frequent disassembly for checking and maintenance, ESNA offers all standard types and sizes of Elastic Stop Nuts with the new nylon locking inserts.

Reusable up to 200 times with remarkably constant torque characteristics, these new Elastic Stop Nuts offer the one-piece construction, the shock resistance, and the moisture-seal features that many manufacturers now depend upon in the standard Elastic Stop Nuts.

One of these Elastic Stop Nuts is probably the solution to your most troublesome fastener problem. It will pay you to look into the self-locking performance of Elastic Stop Nuts. For information, write for a new, free booklet. **Elastic Stop Nut Corporation of America,** 2330 Vauxhall Road, Union, New Jersey, Dept. N5-22.

ELASTIC STOP NUTS

HIGH TENSILE

ANCHOR

HIGH TEMPERATURE

SPLINE

CLINCH

GANG CHANNEL

NYLON CAP

NYLON AND FIBER INSERT TYPES ARE QUALIFIED TO SPEC. AN-N-5

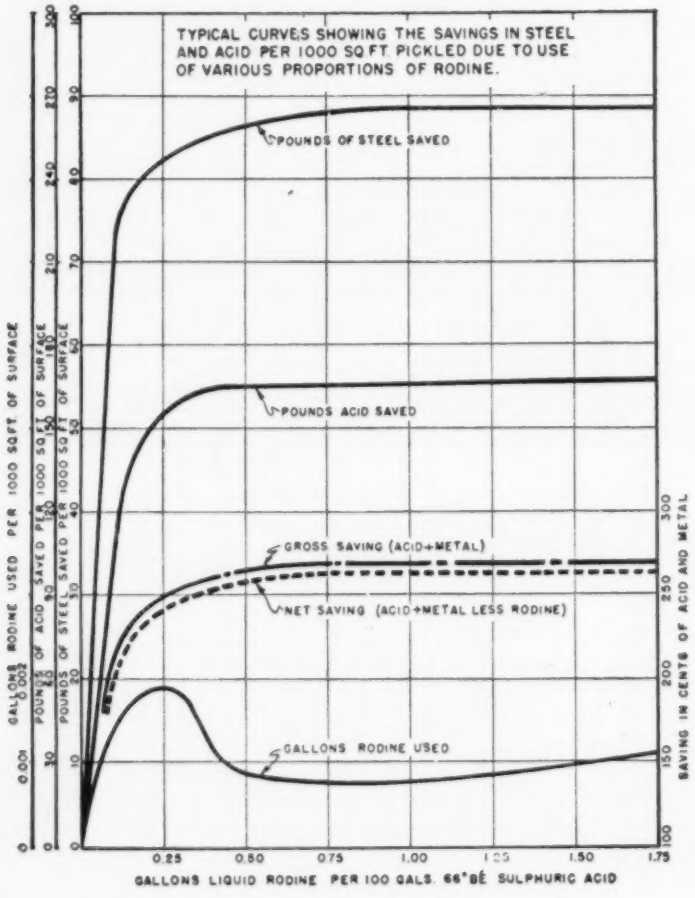
AMERICAN CHEMICAL PAINT COMPANY

AMBLER CHEMICALS ACP PROCESSES PENNA.

Technical Service Data Sheet

Subject: EFFICIENT PICKLING WITH "RODINE"®

A. SAVINGS POSSIBLE WITH "RODINE"


TYPICAL CURVES SHOWING THE SAVINGS IN STEEL AND ACID PER 1000 SQ FT. PICKLED DUE TO USE OF VARIOUS PROPORTIONS OF RODINE.
POUNDS OF STEEL SAVED
POUNDS ACID SAVED
GROSS SAVING (ACID+METAL)
NET SAVING (ACID+METAL LESS RODINE)
GALLONS RODINE USED
GALLONS RODINE USED PER 1000 SQFT OF SURFACE
POUNDS OF ACID SAVED PER 1000 SQ FT OF SURFACE
POUNDS OF STEEL SAVED PER 1000 SQ FT OF SURFACE
SAVING IN CENTS OF ACID AND METAL
GALLONS LIQUID RODINE PER 100 GALS. 66°BÉ SULPHURIC ACID
0.25
0.50
0.75
1.00
1.25
1.50
1.75

B. TYPICAL APPLICATION OF "RODINE"

Pickling shell cases in uninhibited muriatic or sulfuric acid contributes to their embrittlement and makes it difficult to draw them without breakage. By adding a small amount of "Rodine" to the pickle bath, embrittlement is suppressed and more than enough acid is saved to pay the costs of the inhibitor.

CHEMICALS ACP PROCESSES WRITE FOR DESCRIPTIVE FOLDER ON "RODINE" AND INFORMATION ON YOUR OWN PICKLING PROBLEM. CHEMICALS ACP PROCESSES

melt and therefore holds the instrument throughout all ranges of temperatures, providing a good thermal coupling between the surface to be measured and the instrument. Also, furnished with the thermometer is a small magnetic clamp which will hold it securely in place when applying it on steel dies or other ferrous surfaces. The thermometer may be placed on pipes carrying heated or cooled liquid by affixing it in place by either the magnetic clamp or the silicone grease.

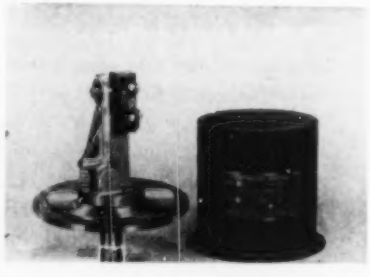
The thermometer has been thermodynamically designed to produce a thermal instrument which indicates the temperature from the back of the instrument only. A highly reflective evaporated mirror on the dial insures the thermal element against external radiation. The range is 0 to 300 F calibrated in 2 deg increments. The Model 310 surface thermometer is 2 in. in diameter.

Phaostron Co., 151 Pasadena Ave., Los Angeles 64, Calif.

Water Tight Temperature Control Unit

Designed to be water, vapor, and dust tight, the model V-1C temperature control unit may be used for any temperature from —200 F to 1,400 F with standard tubes, and up to 1,800 F with special tubes.

The base is cast aluminum, ribbed



to save weight, is tapped for ½ in. iron pipe size electrical conduit or pipe, and is interchangeable with the other instrument heads. It is supplied with positive snap action micro switches, either normally open, normally closed for single pole double throw. Manual reset switches are also available.

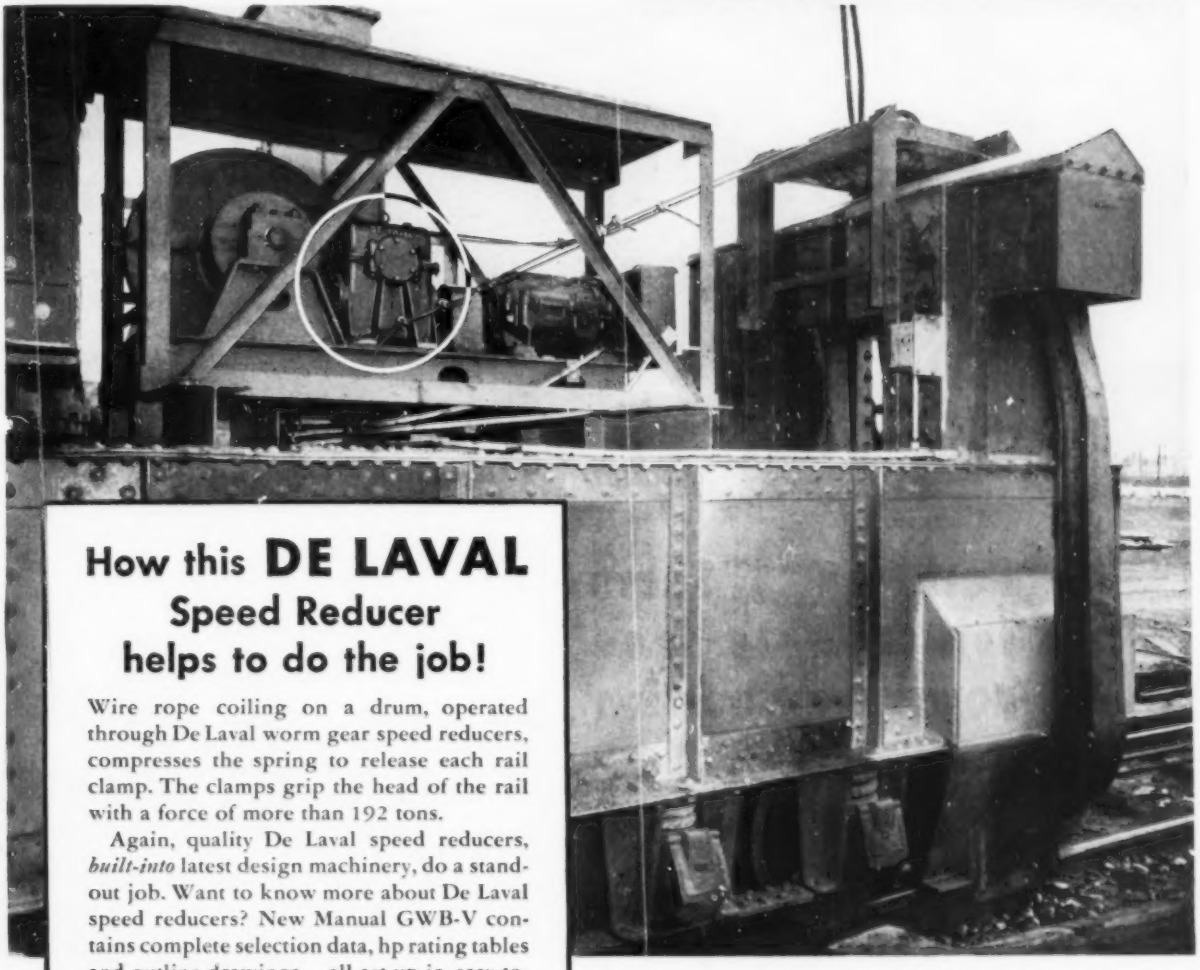
Burling Instrument Co., 5 Vose Ave., South Orange, N. J.

High Voltage Tester

The main body of this voltage tester is a high dielectric, one piece molded case, giving strength and electrical protection even under moist conditions.

No Free Ride Today!

Wind whistling past a 1,800-foot ore bridge runway occasionally gave this big cable-operated bridge a free ride! To prevent this, a set of spring-loaded rail clamps was installed on the legs of the bridge, thus anchoring it securely.



How this DE LAVAL Speed Reducer helps to do the job!

Wire rope coiling on a drum, operated through De Laval worm gear speed reducers, compresses the spring to release each rail clamp. The clamps grip the head of the rail with a force of more than 192 tons.

Again, quality De Laval speed reducers, *built-into* latest design machinery, do a standout job. Want to know more about De Laval speed reducers? New Manual GWB-V contains complete selection data, hp rating tables and outline drawings...all set up in easy-to-use form. Write for your copy today.

DE LAVAL *Speed Reducers*

BUILT TO BE *BUILT-INTO* A QUALITY PRODUCT

DE LAVAL STEAM TURBINE COMPANY • TRENTON 2, NEW JERSEY

DL108R

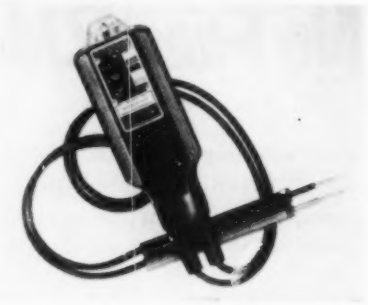
you

furnish the specifications —we'll produce the gears . . .

Perkins *custom-made* Gears for trouble-free power transmission

PERKINS MAKES TO CUSTOMERS' SPECIFICATIONS IN ALL MATERIALS, METALLIC AND NON-METALLIC: *bevel gears, ratchets, ground thread worms, spiral gears, worm gears, helical gears, spur gears with shaved or ground teeth.*

Perkins Machine & Gear company
west springfield massachusetts



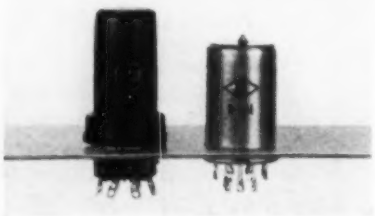
The one-piece molded case has a slotted receptacle on each side which provides a test mount for either prod. When the tester is not in use, the prods may be inserted in the bottom end of the receptacle, shielding the sharp points.

The new prods have four-inch fibre insulators and hardened flat insulated steel points sharpened to pierce insulation. Voltage range covers 110-220-440-550 v a-c, 125-250-600 v d-c, and testers are available for low voltage and 400 cyc systems.

Square D Co., 6060 Rivard St., Detroit 11, Mich.

4 Pole, Double-Throw Relays For Aircraft

The new Diamond H 4-pole, hermetically sealed miniature double throw relays for use in aircraft, have been designed to meet the USAF specifications MIL-R-5757, and other



requirements. Applications for air, marine and ground include: guided missiles, rockets, supersonic and high altitude aircraft; radar, geophysical apparatus, and other devices in which it is necessary to provide light weight and miniaturization under conditions of high or low temperature, vibration and shock.

Test data sheets are said to show that the units give operational shock resistance in excess of 50 G's, while tested models have withstood up to 64 G's with a coil power consumption of 1.5 watts. In the vibration test, the unit operated under vibration in excess of 40 G's, and withstood mechanical shocks of 120 G's. The relay will operate at altitudes up to 80,000 ft.

Contact ratings are 2 amp, 28 v,

HYDRAULIC VALVES—

138 MODELS FOR EVERY NEED!

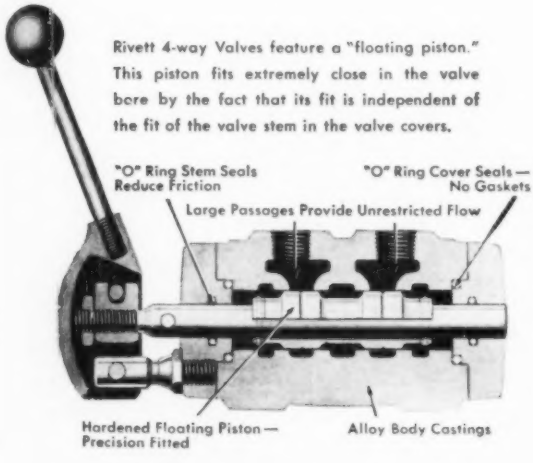
offered in 1500 P.S.I.—3000 P.S.I. for most models

Five piston designs to meet the requirements of any circuit

Six types of operation —hand, foot, cam, solenoid, oil pressure, air pressure

Four types of action —standard, spring return, spring centered, bail detent

Seven sizes available —¼", ⅜", ½", ¾", 1", 1¼", 1½"


"O" Ring Stem Seals Reduce Friction
"O" Ring Cover Seals — No Gaskets
Large Passages Provide Unrestricted Flow
Hardened Floating Piston — Precision Fitted
Alloy Body Castings

Rivett 4-way Valves feature a "floating piston." This piston fits extremely close in the valve bore by the fact that its fit is independent of the fit of the valve stem in the valve covers.

You can plan a more efficient hydraulic circuit by choosing from the wide selection of Rivett valves. Every type of control is available, both direct and remote, including sequence, shut-off, check, relief, unloading, flow control and pilot. Not only does this Rivett variety assure you of a better operating system, but it also offers far greater latitude in design.

With Rivett you get the help of experienced distributors, who will assist in laying out the circuit best suited to your operating requirements.

RIVETT LATHE & GRINDER, Inc.
DEPT. **PE-2,** BRIGHTON 35, BOSTON, MASSACHUSETTS

RIVETT **furnishes a complete power package**

VALVES • CYLINDERS • POWER UNITS

Air and Hydraulic
All sizes and types

FOR HIGHER EFFICIENCY

in high-pressure oil-hydraulic circuits

DENISON HydrOILics

Pumps and Controls

Meet Circuit Needs to 5000 psi

1. DENISON'S SURGE-DAMPING CONTROL *eliminates shock without affecting other circuit functions!* About the size of a garden-hoze nozzle, it is easily installed in any circuit. Adjusts automatically to any working pressure . . . acts with split-second speed . . . can't retard cycling speed.

2. One of the many Denison high-pressure high-volume pumps for either constant or variable volume delivery. Volume control by stem, handwheel, or pressure compensation. Capacities: 2 to 35 gpm. Simplified axial-piston design — rugged, dependable, highly compact.

3. Spool sticking is eliminated in long-cycling, high-pressure operations by Denison's pilot operated 4-way Solenoid Valves. Using system pressures to move the spool through either internal or external pilot action, they assure smooth, quick positive action under all conditions. ¾" and 1½" sizes.

Denison has the answers to today's increasing needs for complete packaged power units built for long life and extra efficiency in high pressure oil-hydraulic systems of almost every type. Write for information on HydrOILic Pumps, Valves, Controls, Pumping Units, Fluid Motors and other components or for recommendations on your specific needs!

The DENISON Engineering Co., 1157 Dublin Rd., Columbus 16, Ohio

DENISON
Pumps and Controls

d-c, 2 amp, 115 v, a-c including 400 cycle; inductive, non-inductive and motor loading. Contact overload rating is 12 amp, 28 v; 20 sec. Special relays can be supplied with resistances ranging from 10 ohms to 20,000 ohms on the coil. Drop-out voltage is 7 v or less. Soldered connections or plug-in terminals may be used. Transit time is approximately one millisecond, and the units are said to be free from chatter and resonance. Insulation resistance is in excess of 500 megohms. The finish offers good resistance to acids and salt spray. Operating temperature range is from minus 65 C to plus 200 C.

The Hart Mfg. Co., 110 Bartholomew Ave., Hartford, Conn.

Unit Magnetizes Odd Shaped Parts

The model LG5 Electronic Magnetizer is a compact, self-contained ignition controlled unit for magnetizing simple and complicated shapes of permanent magnets. Complex assemblies such as p-m motors, meters, magnetic phono-cartridges, magnetic pulleys, novelties incorporating permanent magnets, etc., can be magnetized to the maximum possible intensity after final assembly. Adjustable intensity of magnetization, automatic voltage regulation, manual and remote control and automatic timing of magnetizing pulses are some of the features.

Leo Klein-Electronics, 2404 S. LaBrea Ave., Los Angeles 16, Calif.

Flexible Refrigerant Hose Assembly

Because it contains no metal, a new type hose assembly for refrigerants is unaffected by repeated flexing, and will withstand the vibration and torsional stress that fatigue metal lines. Besides absorbing vibration and reducing noise, the lines flexibility permits servicing of pull-out units. The center tube is of compar, which is impermeable to Freons, and Methyl Chloride. The compar tube has two coverings of reinforcing braid, a bonding agent, and a synthetic cover.

The assemblies are equipped with gas tight fittings and are available in ¼, ⅜, ½ and ⅝ inch hose ID. These assemblies have the Underwriters' Laboratory approval for factory installations in self-contained refrigeration systems containing not more than 20 lb of a group one refrigerant.

Resistoflex Corp., Belleville 9, N. J.

MEETINGS

February 18-19

NATIONAL ASSOCIATION OF ALUMINUM DISTRIBUTORS—First Annual Meeting, Drake Hotel, Chicago, Ill.

February 25-26

MATERIALS HANDLING CONFERENCE—Technical Extension Division, Purdue University, Lafayette, Ind.

March 3-7

AMERICAN SOCIETY FOR TESTING MATERIALS—Spring Meeting, Hotel Statler, Cleveland, Ohio.

March 11-14

SOCIETY OF THE PLASTICS INDUSTRY—Fifth National Plastics Exposition, Convention Hall, Philadelphia, Penna.

March 17-21

AMERICAN SOCIETY OF TOOL ENGINEERS—Annual Meeting and Industrial Exposition, Chicago Amphitheatre, Chicago, Ill.

March 18-19

STEEL FOUNDERS SOCIETY OF AMERICA—Edgewater Beach Hotel, Chicago, Ill.

March 22-April 6

CHICAGO INTERNATIONAL TRADE FAIR—Navy Pier, Chicago, Ill.

March 30-31

PACKAGING MACHINERY MANUFACTURERS INSTITUTE—Semi-Annual Meeting, Hotel Dennis, Atlantic City, N. J.

April 1-4

NATIONAL PACKAGING EXPOSITION AND CONFERENCE ON PACKAGING, PACKING AND SHIPPING—Atlantic City Auditorium, Atlantic City, New Jersey.

April 21-24

SOCIETY OF AUTOMOTIVE ENGINEERS—National Aeronautic Meeting and Aircraft Engineering Display, Hotel Statler, New York City.

April 29-30

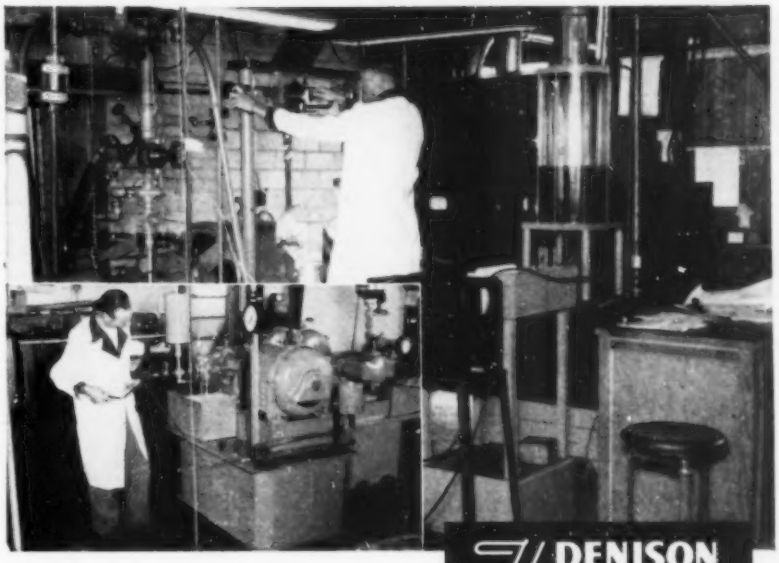
METAL POWDER ASSOCIATION—1952 Metal Powder Show and Eighth Annual Meeting. Drake Hotel, Chicago, Ill.

May 5-16

BRITISH INDUSTRIES FAIR—London and Birmingham, England. New York Offices, 30 Rockefeller Plaza, New York 20, N. Y.

HYDROILIC RESEARCH DOES IT

with constant advancement in designs and methods



DENISON HydrOILics

Pumps and Controls

Shown on Opposite Page are Typical Examples

Applying the full advantages of oil-hydraulic equipment to new requirements that play a major part in today's fast-moving industrial progress, has been the work of a continuous research and development program at Denison for many years.

As a result, press equipment has been reduced in bulk and complexity . . . its speed and efficiency have been increased for all types of production jobs . . . and newly developed all-automatic control features slash costs even on short run production jobs. Pumps of improved design, with full emphasis on efficiency at high pressures, are now a reality. Greater accuracy has been incorporated into pressure controls for all types of circuit needs up to 5000 psi. Tooling designs and methods that reduce scrap losses, boost production rates and improve the quality of work are now in wide, daily use because of procedures developed at Denison.

Recently, special research in applying high-pressure hydraulics to new and bigger commercial and defense-production needs has brought remarkable gains in many phases of industry.

This continuing research program has made Denison a preferred source for new, improved equipment, better methods, and advanced ideas — like the valves that *eliminate* hydraulic shock and spool-sticking, described on the opposite page. You can count on Denison for *better* hydraulic equipment.

WATCH FOR NEW PRODUCTS TO BE ANNOUNCED SOON!

The DENISON Engineering Co., 1157 Dublin Rd., Columbus 16, Ohio

DENISON

Oil-Hydraulic Equipment

Help Lower Unit Production Cost to Meet Competition *Profitably . . .*

Simplified screw driving, bolt setting and nut running mean lower unit cost. This is possible with Pheoll products because they are inspected through all manufacturing steps from coil wire or bar stock to the finished product.

All threads, whether rolled or cut, are carefully gauged to American Standards. Screw and bolt heads are formed, slotted or recessed to meet rigid engineering requirements. Overall quality of the finished product is uniformly high. Precision head formation on all bolts as well as engineered slots and recesses in all screws means less wrench and driver slippage.

Pheoll engineers will recommend the correct type, size and finish of standard or special screws, bolts and nuts for your needs.

WHAT PHEOLL INDUSTRIAL FASTENERS MEAN TO YOU

- Simpler and speedier assemblies.
- Less worker fatigue — more units.
- Improved product appearance.
- Added latitude in product design.
- Immediate and dependable source for standardized, interchangeable screws, bolts and nuts especially suited to mass production.

CHECK THESE PHEOLL PRODUCTS FOR YOUR NEEDS

- ☐ Machine Screws
- ☐ Sems
- ☐ Tapping Screws
- ☐ Square Head Set Screws
- ☐ Threaded Cutting Screws
- ☐ Cap Screws
- ☐ Phillips Recessed Head Screws
- ☐ Machine Bolts
- ☐ Wing Nuts
- ☐ Knurled Nuts

Write for literature

Pheoll MANUFACTURING COMPANY
5709 ROOSEVELT ROAD
CHICAGO 50, ILLINOIS
SCREWS • BOLTS • NUTS

ENGINEERING ABSTRACTS

Gas Turbine Bearing Lubrication Problems

Abstracted from "Lubrication—Bearing Problems In Aircraft Gas Turbines" by E. M. Phillips, General Electric Co., Mechanical Engineering, December 1951.

THE SUCCESS OF THE GAS TURBINE, like that of any other high-speed rotating apparatus, is dependent upon most careful attention to the design and application of each of its parts. No part or detail can be considered unimportant or exempt from this rule. The gas-turbine main shaft bearings and their lubrication cannot be considered an exception. The extensive damage resulting from failure of a bearing designed for supporting a high-speed rotor easily can force the abandonment or expensive redesign of a unit other-wise satisfactory.

The requirements for most bearings supporting a high-speed rotor might be listed as follows:

1. Ability to support the imposed load.
2. Minimum power loss.
3. Minimum wear.
4. Minimum scuffing and pitting damage.
5. Avoidance of excessive vibration.

These criteria assume the presence of sufficient lubricant to prevent metallic contact and to carry away the heat generated. However, bearings designed for aircraft gas turbines and the lubricant for them must satisfy much more than these basic requirements. They must operate satisfactorily at any temperature between —65 and +250 or 275 F. Because of the weight penalty and the high cooling-air temperature with high-speed jet-propelled aircraft, it becomes difficult to maintain the top temperature limit in many designs, and it often becomes desirable that the limit be increased to at least 350 F. The gas turbine must start and accelerate quickly without excessive power requirement and with an ambient temperature at any point in the range from —65 F to +160 F. Because of the feedback of heat from the turbine buckets, the turbine bearing will reach a temperature in the neighborhood of 450 to 500 F after shutdown and after the flow of lubricant has stopped. This results in the evaporation of nearly all lubricant remaining in the bearing and oxidation of the

PUMPS
FOR COOLANTS, LUBRICANTS, AND ABRASIVE LIQUIDS

PUMPS
POSITIVE DISPLACEMENT AND IMPELLER TYPES

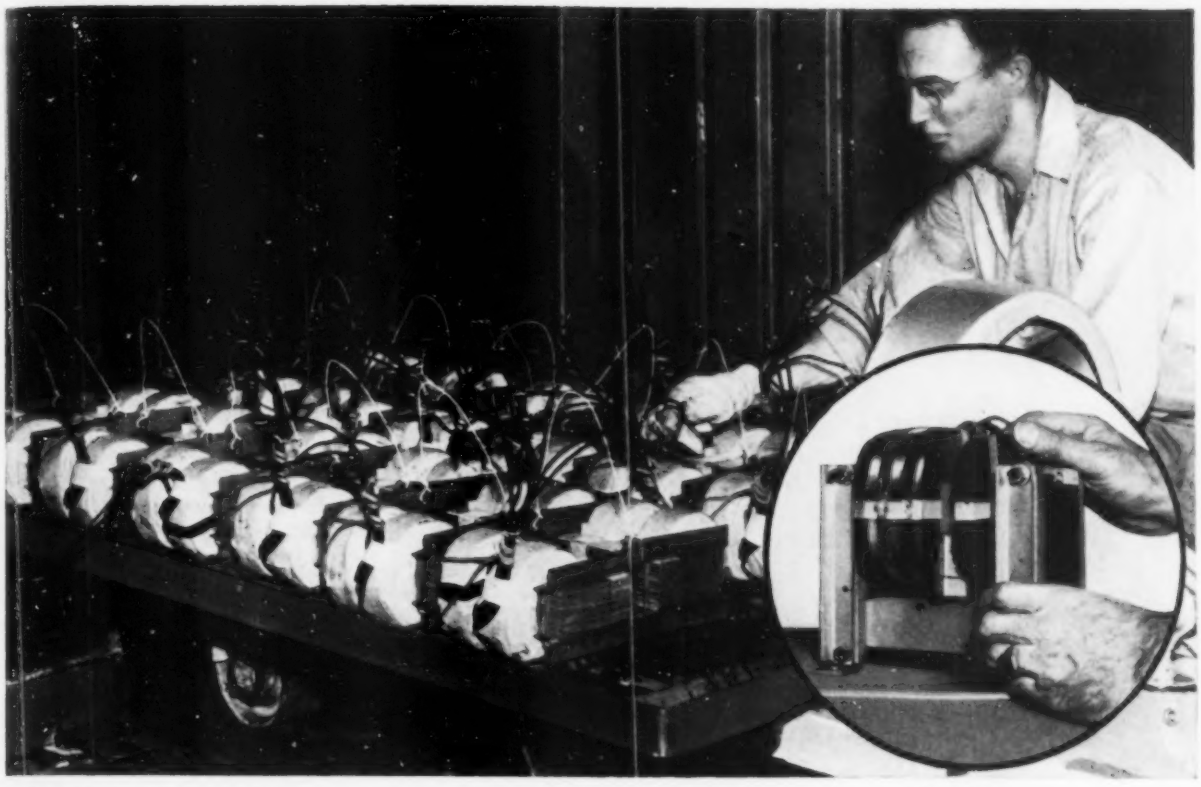
PUMPS
J. I. C. STANDARDS OR DIRECT MOTOR CONNECTED

PUMPS
DEPENDABLE, ECONOMICAL, EFFICIENT

STANDARD OR SPECIAL, FOR EVERY MACHINE TOOL AND INDUSTRIAL USE

Rollway PUMPS

Pioneer PUMP
& MANUFACTURING CO., INC.
19664 JOHN R STREET
DETROIT 3, MICHIGAN
WRITE FOR CATALOG



"Costs cut, output tripled with Irvington No. 123 Varnish"—HANOVIA

Chem. & Mfg. Co.

"We've improved the quality and cut the production cost of our transformers by impregnating the *entire transformer* with IRVINGTON No. 123 Internal Curing Varnish." That's the statement made by Mr. N. J. Frizen, Plant Manager of Hanovia Chemical and Manufacturing Co., the world's largest producer of ultra-violet equipment for industry and the medical profession.

"Fast baking schedules possible with No. 123 have enabled us to triple the output of our ovens. We're sure of a thorough cure even on these speeded-up schedules—we've found that with No. 123 there's no danger of wet, sticky interiors."

Here are some *additional* advantages of No. 123:

Excellent flexibility and oilproofness. Good resistance to moisture and chemicals. Firm adherence to underlying surfaces. Integrated bonding of units to withstand stress and strain. Long life at temperatures up to 130° C.

Get the full story on this outstanding insulating varnish—mail the coupon for technical data sheet.

Send this convenient coupon today

Irvington

VARNISH & INSULATOR COMPANY

Irvington 11, New Jersey

Plants: Irvington, N. J.; El Monte, Calif.; Hamilton, Ontario, Canada

PE-2-52

Irvington Varnish & Insulator Co.
6 Argyle Terrace, Irvington 11, N. J.

Gentlemen:

Please send me technical data sheet on Irvington No. 123 Internal Curing Insulating Varnish.

Name ..... Title .....

Company .....

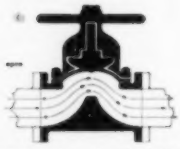
Street .....

City ..... Zone ..... State .....

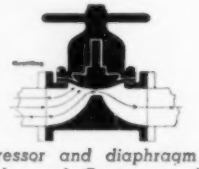
If your product requires the valving of "hard-to-handle" fluids . . .

HILLS-McCANNA
Saunders Patent
diaphragm valves
provide
the answer

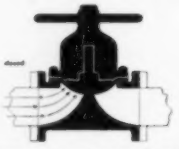
THIS SIMPLE PRINCIPLE ASSURES POSITIVE LEAK TIGHT VALVING



Compressor is raised, lifting diaphragm by means of a stud molded into the material.



Compressor and diaphragm partially lowered. Compressor design guides and supports diaphragm.



Compressor presses diaphragm tightly against weir, pinching off flow and making a tight seal.

Leakproof valving of air . . . corrosive materials . . . slurries . . . solids . . . volatile and viscous substances

Hills-McCanna Diaphragm Valves can eliminate the problems involved in valving many of the so-called "hard-to-handle" fluids. By employing a simple pinch clamp principle, Hills-McCanna valves put an end to leakage, repacking and contamination.

Hills-McCanna Valves are available handwheel or lever operated or for operation by pneumatic or hydraulic cylinders, diaphragm motors, electric motors, etc. Choice of 14 diaphragm materials, 49 body materials. Sizes from ⅜" to 14". Suitable for pressures to 150 psi., temperatures to 180° F. (higher with special materials). Screwed or flanged connections.

Write for Catalog V-52, HILLS-McCANNA CO., 2444 W. Nelson St., Chicago 18, Ill.

HILLS-McCANNA
saunders patent diaphragm valves
Also Manufacturers of Proportioning Pumps
Force Feed Lubricators • Magnesium Alloy Castings

remainder on the bearing surfaces. In starting up a bearing coated in this manner, it must not suffer damage while operating prior to the flow of lubricant being restored to the bearing. During airplace maneuvers the bearing must carry radial loads as high as fifteen times normal gravity, and maximum thrust loads at somewhat greater than fifteen times normal. The bearing also must accommodate a considerable angular movement of the rotor during these maneuvers.

More recent designs of journal-type bearings shown in Figs. 1 and 2 have been applied to aircraft turbosuperchargers. Fig. 1 shows the application of a silver-lead-indium journal bearing which is machined so as to provide a bell-mouth effect for extra clearance

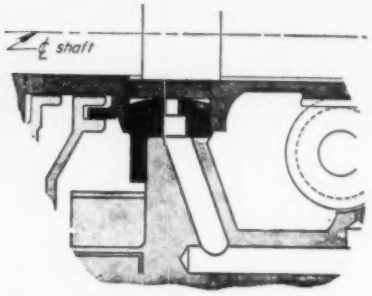


Fig. 1—Turbosupercharger Journal bearing — silver-lead-indium.

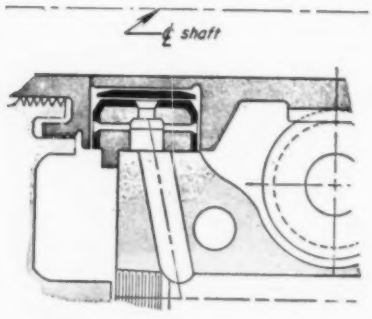


Fig. 2—Tubosupercharger bearing — floating sleeve.

at the ends to accommodate the angular movement of the shaft during airplane maneuvers. In order to call attention to this feature, the bellmouth is shown somewhat exaggerated.

Fig. 2 shows a floating sleeve type of journal bearing. This bearing has two theoretical advantages: (1) lower relative peripheral speed because of the rotation of the sleeve at partial speed, and (2) additional freedom to accommodate the angular movement during maneuvering, because of the increased total oil-film thickness. Both of these designs proved satisfactory for development in turbosupercharger appli-

DIE CASTING washes out the production "blues"

Montgomery Ward's modern washing machine with gyroscopic drive—a gearless mechanism designed for trouble-free service. (Built for Montgomery Ward by Apex Electrical Mfg. Co., Cleveland, Ohio)

CASE HISTORIES FROM MT. VERNON FILES

Die Casting eliminates those gloomy high cost factors that often threaten to "soak" you plenty once your projects begin to take shape on the drawing board

For instance, it was the ***reduced cost of production,*** without sacrifice of quality, that determined the makers of Montgomery Ward's "Supreme" Automatic Washing Machine to specify die casting

The aluminum basket hub (A) was originally sand cast. Die casting has reduced the initial cost of the casting, and cut machining costs.

The main bearing carrier (B) was originally a steel tube and flange, arc welded. Redesigned for die casting, this part is produced at a saving of approximately $2.50.

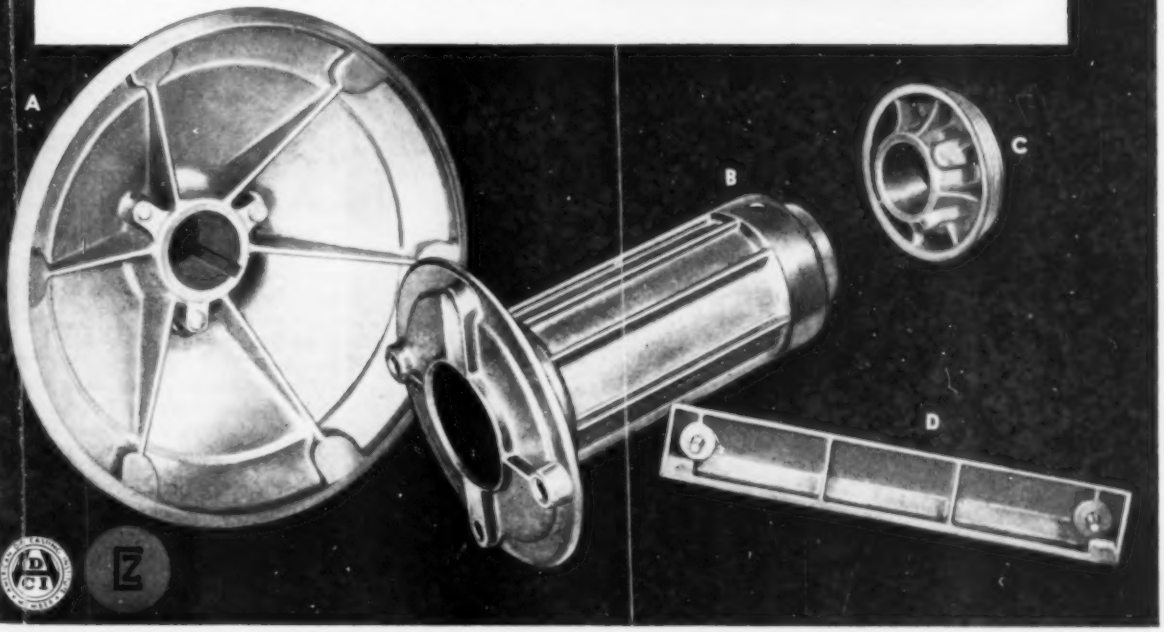
The cam collar (C) was originally turned from steel bar stock. Die cast, the item costs approximately 60¢ less to produce.

The portion of the lid hinge (D) was originally cast brass. As an aluminum die casting, about 25¢ have been pared from its production cost.

While it may be noted that prior to the adoption of die casting this washing machine was not in high volume production—and, consequently, initial unit costs probably did not represent the minimums attainable—yet it is certain that only die casting could effect the large savings realized

Before **you** schedule a manufacturing procedure, profit by ***consulting with us.*** We've helped many a producer to wash out high costs from his production picture . . . and obtain better products to boot! We'll gladly put our experience and facilities to work for you

MT. VERNON
DIE CASTING CORP.
MT VERNON, NEW YORK



of product or process
demands
dependable timing
specify
Cramer
time
delay
relay

Widely used in industrial controls for heat treating, for the control of plastic and injection molding, lapping, induction heating, mixing and agitation, purging gas fired ovens etc. — where accuracy of timing improves quality, reduces supervision or vitally protects the process or equipment itself — the Cramer Type TEC Time Delay Relay provides an adjustable time delay between the operation of a control circuit and the subsequent closing or opening of a load circuit. Designed for dependable, trouble-free service . . . compact construction . . . extremely accurate.

For complete details of the Type TEC and other dependable Cramer timing instruments — send today for copy of new Cramer Catalog.

THE R. W. CRAMER CO., INC.

BOX 7, CENTERBROOK, CONN.

Builders of dependable timing devices for more than 25 years.

INTERVAL TIMERS • TIME DELAY RELAYS • RESET TIMERS • CYCLE TIMERS
PULSE TIMERS • RUNNING TIME METERS • PERCENTAGE TIMERS

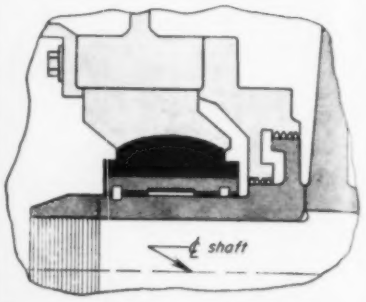


Fig. 3—Aircraft gas-turbine bearing — journal type.

tions. The disadvantages of higher power loss (than for antifriction bearings) and higher low-temperature starting-torque requirement, together with limited provision for angular movement of the shaft during maneuvering, make their application, as presently designed, to aircraft gas turbines very questionable.

The author's company has found that for aircraft gas-turbine applications ball and roller bearings best meet the requirements. In the early development of one unit, babbitted journal bearings with babbitt facing on one of the bearings for supporting thrust were used. This is shown in Fig. 3. However, because of the high power losses and the high starting-torque requirements due to the main shaft and accessory gear-drive journal bearings, this design was modified to utilize ball and roller bearings throughout for the production model. The ball and roller bearings for some units have been lubricated by an oil mist wherein a metered oil supply is fed into an atomized by an air jet at the nozzles lubricating each of the bearings.

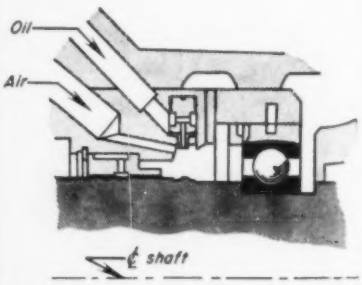
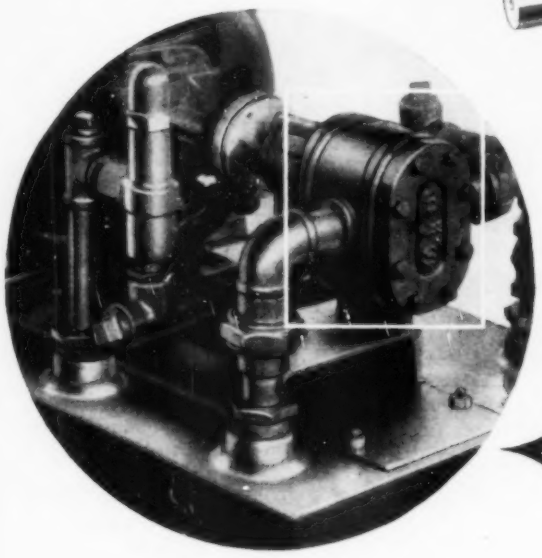


Fig. 4—Aircraft gas-turbine bearing — mist-lubricated, metered at bearing.

Fig. 4 shows such a system in which the metering nozzle is adjacent to the bearing, while Fig. 5 shows a design in which the oil for each of the bearings is metered by a common multipoint regulator. Because of the limitation is bearing cooling, the difficulty

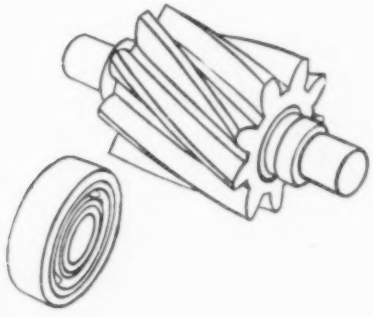
(Continued on Page 258)

Stock Pumps with "Custom-Made" Performance...



for hydraulically-operated machines

Nos. 53 and 55
ROTARY GEARED PUMPS
with Helical Gears and Roller Bearings



Smooth, quiet operation . . . uniformly dependable flow . . . extended pump life without maintenance troubles! These are advantages you can count on, when you specify Brown & Sharpe Rotary Geared Pumps with helical gears and roller bearings as original equipment for hydraulically-operated machines.

Designed with extremely accurate helical gears and roller bearings, Brown & Sharpe No. 53 and 55 Pumps have served as standard equipment for low-pressure hydraulic systems on a wide variety of machines, such as stokers, shoe machinery and machine tools and also for many transfer applications.

Capacities: No. 53—4 to 23.3 gals. per min. at 0 lbs. pressure; No. 55—9 to 34.1 gals. per min. at 0 lbs. pressure. Direct drive, or may be driven by pulley or gear. Run in one direction only, either clockwise or counterclockwise.

Write for Pump Catalog containing complete specifications. Brown & Sharpe Mfg. Co., Providence 1, R. I., U.S.A.

WE URGE BUYING THROUGH THE DISTRIBUTOR

Brown & Sharpe B·S

DESIGNERS' DREAM COME TRUE!

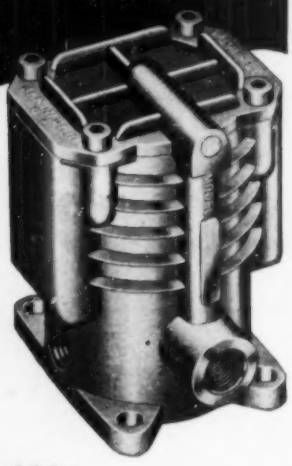
The *New* VALVAIR SOLENOID PILOT VALVE

Outstanding Features

in a New Valve PRICED ATTRACTIVELY!

- OVER 20,000,000 CYCLES
- CORROSION-PROOF
- NO OVERHEATING
- MANIFOLD MOUNTING AVAILABLE

SIZE: ¼" pipe tap, orifice ⅛" or 3/16".



The NEW Valvair Solenoid Pilot Valve is offered in 2-way and 3-way models, normally open or normally closed. Coils are completely sealed. Only two moving parts: spring and plunger. Valve life is almost unlimited.

VALVAIR CORPORATION • 961 Beardsley Ave., Akron 11, Ohio

Affiliate: Sinclair-Collins Valve Company

Write for new Bulletin E-2.

Rely Upon Valvair 2-WAY 3-WAY 4-WAY

The Most Economical

Made of fewer parts, each part of specially selected steel, individually hardened for a specific purpose — they last longer.

CURTIS UNIVERSAL JOINTS

Not only do they give efficient service for a longer period of time but they are easier to install, quicker to assemble and disassemble. 14 standard sizes to choose from—with either solid or bored hubs. Facilities immediately available to produce specials to specifications.

ONLY CURTIS OFFERS ALL THESE ADVANTAGES

Availability — 14 sizes always in stock.

Simplicity — fewer parts, simpler construction.

Government Tests — complete equipment for government tests in our plant.

the only Universal Joint with the "Telltale" Lock Ring (patented)

Write today for free engineering data and price list

CURTIS UNIVERSAL JOINT CO., INC.

6 BIRNIE AVENUE SPRINGFIELD, MASS.

As near to you as your telephone

A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

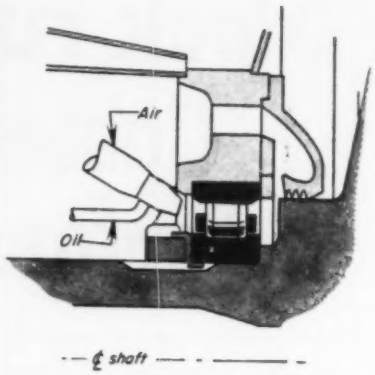


Fig. 5—Aircraft gas-turbine bearing — mist-lubricated, metered at regulator.

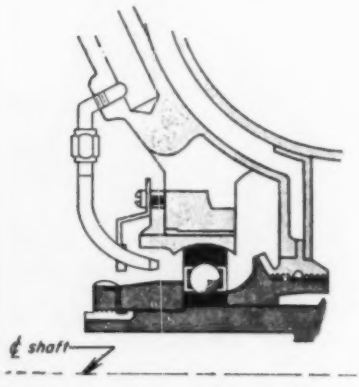


Fig. 6—Aircraft gas-turbine bearing — a solid-oil-jet-lubricated type.

of separating the oil from the air or handling the large return volume of mist, and the resulting high oil-consumption rates, these systems have been replaced in the author's company by solid oil-jet lubrications in aircraft gas-turbine applications. However, both the systems illustrated in Figs. 5 and 6 performed satisfactorily, except as indicated by the foregoing limitations.

Fig. 7 shows the antifriction-type bearings with solid oil lubrication. In this design lubricating oil is fed through a nozzle adjacent to the ball or roller bearing and directed toward the clearance between retainer and

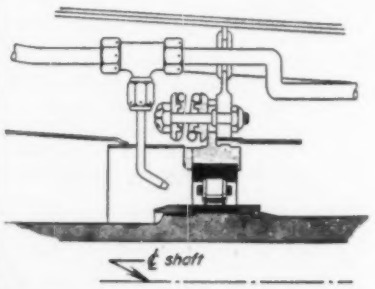


Fig. 7—Aircraft gas-turbine — solid-oil-jet-lubricated by anti-friction bearings.

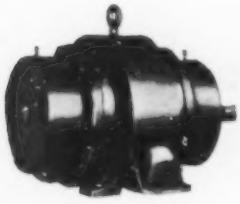
GUARD YOUR PRODUCTION AGAINST the Hazard of SPLASHING LIQUIDS

WITH

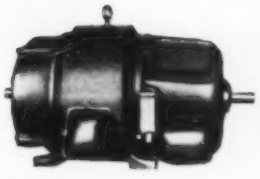
Century SPLASH PROOF MOTORS

Century 7½ HP Type RS Single Phase Repulsion Start Induction Brush Lifting Splash Proof Motor.

1 to 7½ HP Direct Current Splash Proof Motor.



150 to 400 HP Type SC Squirrel Cage Induction 3 Phase Splash Proof Motors.



30 to 100 HP Type SR Slip Ring Induction 3 Phase Splash Proof Motors.

1 to 125 HP Type SC Squirrel Cage Induction 3 Phase Splash Proof Motors.

3 to 25 HP Type SR Slip Ring Induction 3 Phase Splash Proof Motors.

1 to 20 HP Type CS Capacitor Start Induction Single Phase Splash Proof Motor.

Keep the vital parts of your motors dry —even when the full force of a hose is turned directly on them. Century Splash Proof motors eliminate production losses due to dripping or splashing liquids or falling solids. They also protect against rain, snow, sleet or hail on outdoor installations.

Century Splash Proof motors are available in a wide range of types and sizes for all popular applications. Other types and ratings are available to meet your electric power requirements. You can specify Century motors with confidence.

Century motors are built in sizes ⅙ to 400 horsepower.

697

Century C MOTORS

CENTURY ELECTRIC COMPANY, 1806 Pine Street, St. Louis 3, Missouri

Offices and Stock Points in Principal Cities

WHY NOT cast a magnesium mousetrap?

Maybe it IS a lousy idea . . .

On the other hand, maybe it's as practical as using cheese for bait.

Frankly, we haven't gotten out a slide rule or put our thinking cap on tight, to figure it out one way or the other. Maybe the mice wouldn't go for it.

But we do know a lot of things WILL be cast in magnesium or aluminum after military requirements are satisfied.

A lot of things no one ever thought would be.

So whatever your plans are; whatever directions they might take; whatever products you might have on scraps of paper, in preliminary drawings, or just plain ideas-on-the-brain . . . . keep an open mind in terms of magnesium or aluminum in sand-cast, semi-permanent or permanent mold form.

Particularly Well-Cast castings.

Naturally.

Well-Made Wood and Metal Patterns • Ampco Bronze Castings

Almost a half-century of Experience

THE WELLMAN BRONZE & ALUMINUM CO.

2519 EAST 93rd STREET • CLEVELAND 4, OHIO

bearing race. A small part of this oil enters the bearing and lubricates the rolling and sliding surfaces. The remainder is deflected by the retainer and races, carrying away heat and cooling these bearing parts. The amount of oil supplied to each bearing is controlled by orifices sufficient to maintain a safe operating temperature limit at the bearing. The oil also must keep the power loss in the bearing and the amount of heat which must be removed in the oil cooler to a minimum.

Viscosity of Lubricants

Since the power loss in a bearing and also the starting torque required become greater as the viscosity is increased, it is desirable to use a lubricant having as low viscosity as possible consistent with load-carrying ability and freedom from evaporation or boiling off of the lighter constituents at the higher operating temperatures encountered. This led to the use of a petroleum oil having a viscosity of 10 centistokes at 100 degrees Fahrenheit. (Army-Navy Aeronautical Specification MIL-O-6081, Grade 1010) for many of the jet-propulsion gas turbines. However, because of the heavy loads on gearing and the wear characteristics of the gears, especially during early running, most builders of propeller-propulsion gas turbines have found it necessary to use a heavier oil in these units. Such an oil with wear-improver additive (MIL-O-6086, Grade M) has been applied.

The experience of some aircraft gas-turbine builders has pointed to a need of a higher-viscosity lubricant for operation above + 20 F and of a still higher viscosity with load-carrying additive where heavily loaded gears are involved. The experience of the author's company indicates that with accurately cut smooth gears, scuffing at high loads occurs at very low speeds only, and that heavy loads can be carried with little wear and without pitting or scuffing on accurately cut smooth surfaces lubricated with light oil. Hertz stresses as high as 120,000 psi have been carried on medium-hardness gears at high speed without scuffing or pitting, whereas a rougher surface will fail at about one half of this value. Rolls of hard material and fine finish have carried loads giving a Hertz stress of 350,000 psi without grief. The smoothness of the surface appears to be the most significant factor.

Turbine-Bearing Requirement

After the gas turbine is shut down, heat stored in the turbine wheel disk flows into the turbine bearing and

since the cooling-lubricant flow has stopped, the bearing heats up and evaporates most of the oil remaining on metal surfaces, leaving only a "varnish-like" deposit. The standard roller bearing used in this location had a roller retainer of free-machining yellow brass with sliding contact on the narrow end shoulders on the inner race. Upon starting-up, during the period before an adequate lubricating film had been established at the bearing surfaces of the retainer with the inner race and with the rollers, the dry bearing experienced seizure and considerable smearing of brass on the steel parts at these sliding surfaces.

Tests have shown that silver-plated retainers last on an average of 77 times as long as the unplated brass retainer (292 min against 3.77 min.). Monel plated retainers have shown even better results.

Ball-Bearing Failure

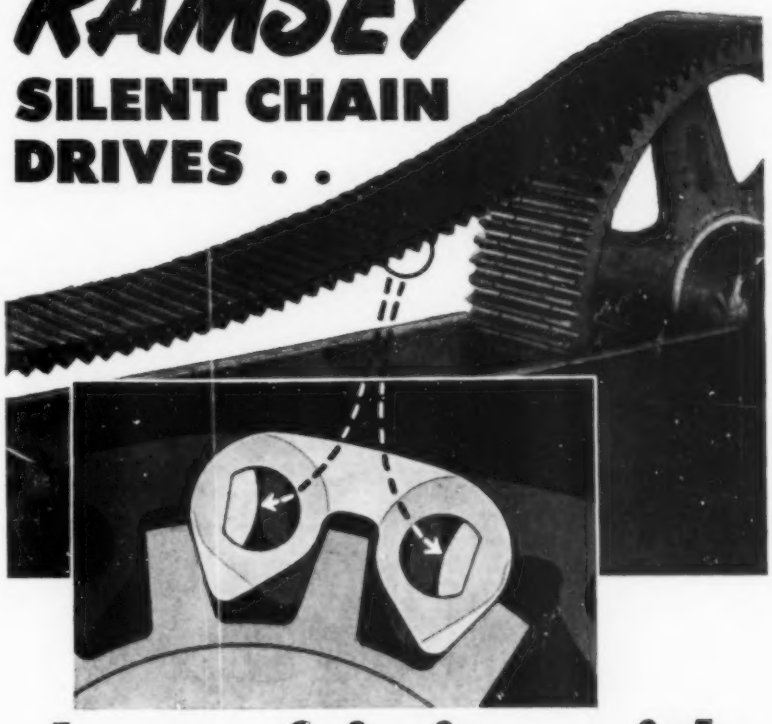
It is important that ball or roller bearings have sufficient clearance so as to prevent binding and the resultant loading from unequal temperatures of inner and outer races, whether caused by heating from friction in the bearing or from conduction from hot parts. Evidences of such insufficient clearance have been discovered in early testing of some units. In an effort to determine the causes of failure in high-speed ball bearings and to verify deductions from indications on test, a laboratory program was undertaken on 50-mm medium series ball bearings, number 310, operating at 13,200 rpm. With a radial load of 30 lb and a thrust load of 200 to 300 lb, failure could be produced by lack of oil or by elimination of internal clearance due to heating of the inner race, combined with pasage of dirt through the bearing. No failure was produced by any of the following when acting alone:

1 High thrust
2 Reverse thrust
3 Unbalanced radial load with vibration at a frequency equal to the rotation speed.
4 Elimination of internal clearance.
5 Lots of dirt (carborundum, steel chips, cast-iron chips, or aluminum chips)—races were marked but no failure resulted.

Larger-Size Roller Bearings

In extending the application of ball or roller bearings in addition to limiting loads and DN-values (diameter multiplied by speed), consideration must be given to the method of lubrication and the design proportions of

RAMSEY
SILENT CHAIN DRIVES . .



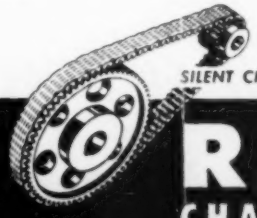
beats friction with rolling action

The "friction-barrier" was broken when Ramsey introduced a chain joint which operated on the friction-free principle of a roller bearing. Friction no longer limits power transmission speed. In fact, speeds of 8929 RPM, 7813 feet per minute have been handled successfully by Ramsey Chains. Instead of pins which rub against their bearing surfaces, Ramsey utilizes a roller bearing action—curved pins actually roll on each other as the chain flows around the sprocket. This patented chain joint all but eliminates friction, with a resultant reduction in heat, wear and vibration. Naturally in a practically friction-free linkage such as this, lubrication is simple—no oil-bath, just a few oil drops a day is all a Ramsey needs.

For a clean drive that delivers positive smooth power in all speed ranges, specify the chain that broke the "friction-barrier"—RAMSEY.

FREE APPLICATION MANUAL FOR ENGINEERS

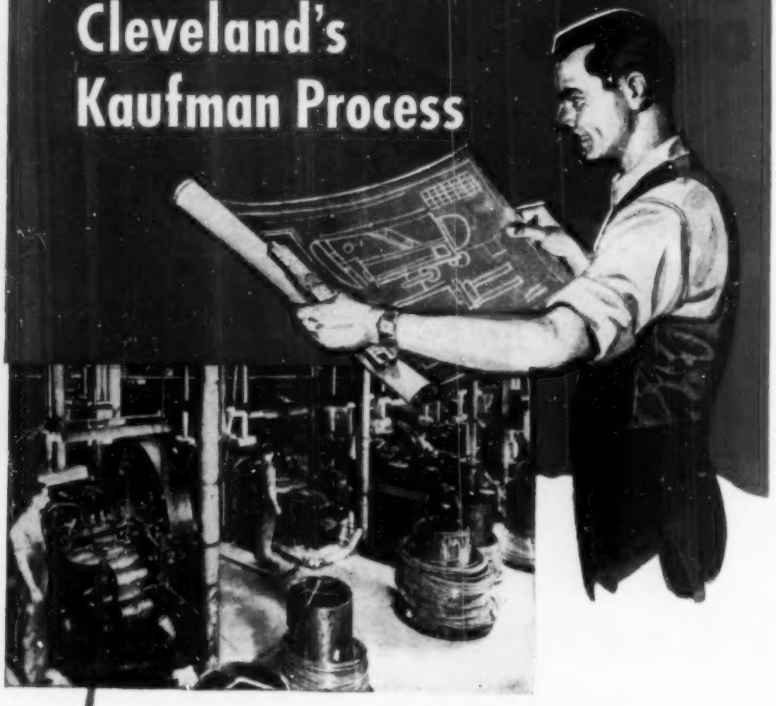
This 60 page book gives you the range and scope of Ramsey Silent Chain Drives—tells you how to work out applications and includes the necessary data on chains, sprockets and pinions. Write for a copy today.



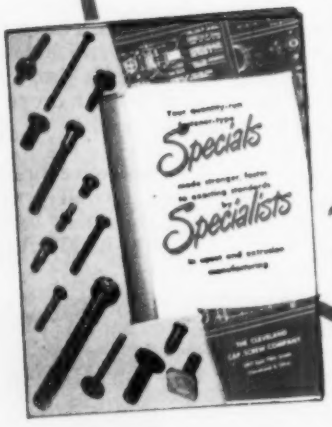
SILENT CHAIN DRIVES — FLEXIBLE COUPLINGS

RAMSEY
CHAIN COMPANY, INC.
5150 BROADWAY • ALBANY, N. Y.

Simplify your special parts* production problem with Cleveland's Kaufman Process



Have your unusual *fastener-type parts made to your specifications by extrusion forging. Cleveland's Kaufman Process guarantees a tougher product, accurate in every dimensional detail—usually ready for use without machining. This method is faster, therefore more economical in most cases. The steel and heat treatment you specify are followed to "the letter".



Relieve your shop of this production problem. Have your quantity-run fastener-type specials made better and faster at Cleveland. Write for folder "Specials by Specialists."

THE CLEVELAND CAP SCREW COMPANY
2936 East 79th Street, Cleveland 4, Ohio

CLEVELAND *Top Quality* FASTENERS

the bearings. The standard method of lubrication had been to supply oil by a single jet and to drain from both sides of the bearing. In a study to determine operating characteristics of a 140-mm light series roller bearing at 7,500 rpm, a test program was initiated on the bearing test stand at the bearing center of the Thomson Laboratory. In attempting to operate with this standard method of lubrication, some bearings could not be brought up to full speed because of chatter, while others operated very noisily at full speed. Examination showed the brass separators to be heavily marked on diagonally opposite portions of the lands riding on the inner race, indicating a tendency of the separators to cock and cause heavy bearing on the narrow lands. Substitution of silver-plated separators showed very little gain. Several methods were found to obtain successful running, as follows:

1 Reduction in the running clearance between the separator and the inner race, thus limiting the amount of tipping permitted.

2 Increasing the width of the separator and inner race.

3 Changing material of separator to Monel metal.

4 Changing the lubrication method to provide an oil jet on each side of the bearing and to restrict the drain on one side.

Vanadium As An Engineering Material

Abstracted from "Pure Vanadium . . . A promising engineering material" Steel, December 31, 1951

VANADIUM is one of the most recent of the rare metals to become industrially available. Pure vanadium metal has been rare, even though alloys of vanadium have been produced in quantity for many years. It is eighth in order of natural abundance of those metals useful for structural purposes. In this respect it ranks ahead of nickel and copper.

Pure, ductile vanadium metal can now be obtained in massive form for remelting, as well as in ingots, bars, sheet and foil. The metal is lighter than iron, has good structural properties, and resists pitting and corrosion by salt spray and sea water. It can be rolled at ordinary temperatures; cold reductions up to 85 per cent have been made without annealing. It can be hot worked with or without protective sheaths, but when rolling or extrusing is done without sheathing, a protective atmosphere is required. In gen-

eral, rolling practice with respect to passes and reduction follows that established for austenitic stainless steels. Since in the case of vanadium there is no discontinuity in effect between hot and cold rolling, the rolling operation can usually be continued right down to room temperature. Pure vanadium machines well and is easily welded with regular shielded arc methods.

Good Machinability

Machinability of pure vanadium appears to be about the equivalent of cold rolled steel. The metal is free-cutting. Tools such as those used for copper with a high rake angle of about 15 degrees and a sufficient clearance angle of 7 to 15 degrees have been used successfully. To produce a good surface finish, high cutting speeds and light cuts can be employed. A light lubricant improves the quality of the machined surface. Vanadium is easier to machine than Monel, nickel, stainless steel and titanium; however, it is not quite so easy as copper, yellow brass, or aluminum.

Vanadium may be bent, stamped and pressed using conventional methods. A Belleville spring was made in a simple lead-lined die. Rubber plungers may also be used.

Vanadium may also be welded using argon shielding and a Heliarc torch. Annealing after welding is not necessary; however, stress relieving around 1100 in inert atmosphere may be used to insure dimensional stability.

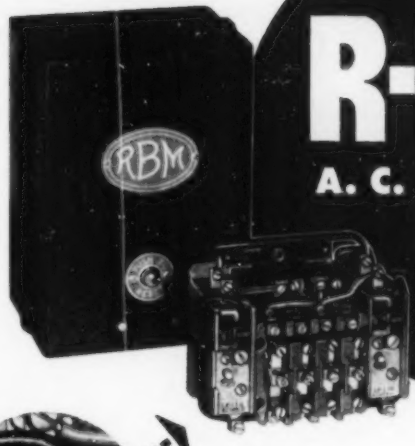
Physical Properties

Physical properties of vanadium metal, as is the case with some of the other rare metals, vary with the oxygen, nitrogen, and carbon contents. Amount of cold working also affects the properties of the metal. Hardness varies from Rockwell B-75 to C-29 and can be fairly well controlled within these limits.

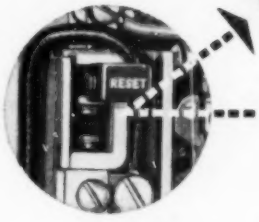
The amount of gases, such as oxygen and nitrogen, in solid solution has a pronounced effect on hardness, ductility and tensile strength. In general, these gases result in increased hardness and tensile strength, and decreased ductility. The only satisfactory method for determining oxygen in vanadium appears to be the vacuum fusion technique.

Density of vanadium is appreciably lower than that of steel and the elastic modulus is relatively high for that density. The modulus-density ratios for steel and vanadium are practically equivalent (3.7 million) and higher than that for titanium, which

NEW!



R-B-M
A. C. MAGNETIC STARTERS
Line Voltage Type



--- With Visible Contact Overload Relays

Heater element cannot be assembled to the starter incorrectly.

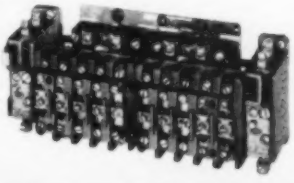
Bi-metallic thermal overload relay assembly replaceable without removing starter from enclosure. Designed for separate mounting without sub-panel assembly.

TRIP-FREE Manual reset is standard. Manual-Automatic Reset available on special order at no extra charge.

R-B-M Size 0 and 1 A.C. Magnetic Starters have identical overall panel mounting dimensions. All parts, except stationary and movable contact assemblies, are common to both sizes.

Ilsco solderless lugs, suitable for #6 maximum wire size, are standard. Screw terminals are available on special order. Magnet coil can be removed without disassembling the starter. Stationary and movable contacts replaceable without disconnecting wiring. Enclosed heater element, expanding U-shaped bi-metal and snap action contact mechanism provide dependable, accurate motor overload protection.

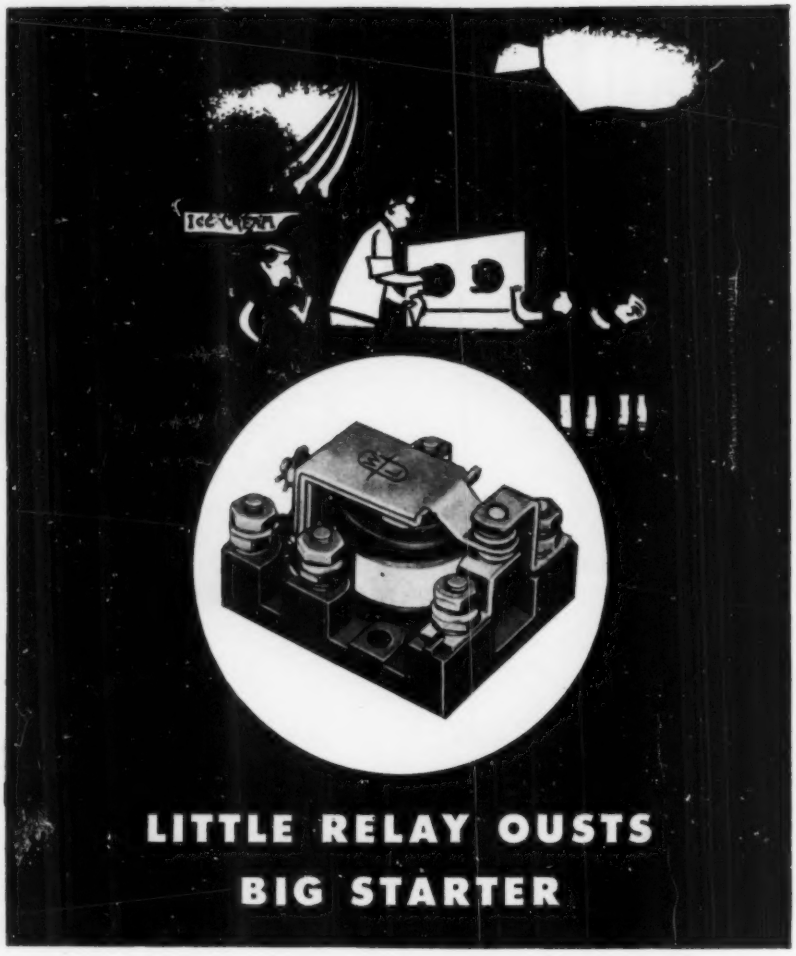
Small overall size, plus indentical mounting dimensions for 10 and 15 ampere 2 to 5 pole contactors, as well as Size 0 and 1 non-reversing starters, make the R-B-M line extremely flexible for control panel layout.



Two 5 pole contactors mechanically interlocked with overload protection on common base. Unwired. Note interchangeability of 25 ampere N.O. contacts and 15 ampere convertible N. O. or N.C. interlocks.

Address Department C-2

RBM
R-B-M DIVISION
ESSEX WIRE CORP.
Logansport, Indiana
MANUAL AND MAGNETIC ELECTRIC CONTROLS
FOR AUTOMOTIVE INDUSTRIAL COMMUNICATION AND ELECTRONIC USE



and saves customer both space and money

An ice cream freezer manufacturer* was perfectly content with the across-the-line starters used in his equipment.

But we got the idea of saving him some room and dollars by substituting Ward Leonard heavy-duty midget *relays.*

It's a really rugged relay, and certain types are Underwriters' listed as motor controllers. Months of testing proved that a standard Ward Leonard relay with just slight changes would do the job of the heavier starter.

It's another case of Ward Leonard "Result-Engineering" Write us for Bulletin 105 on the heavy-duty midget relay, or for *any* control problem, write WARD LEONARD ELECTRIC CO. 63 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

*Sweden Freezer Manufacturing Company, Seattle, Washington.

WARD LEONARD ELECTRIC COMPANY

Result-Engineered Controls Since 1892

RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES

W L

is variously given as 3.1 to 3.6 million. From this comparison, indications are that, other things being equal, vanadium would be the first choice for a structural part in which flexural rigidity was the determining factor. This and data on static tensile properties indicate that vanadium should make a good spring material.

Data on vanadium produced in Westinghouse studies show an ultimate tensile strength of 100,000 psi for annealed vanadium and 140,000 for work-hardened metal. The corresponding hardness values were reported to be 230 VPN for the annealed and 330 VPN for the work hardened. The corresponding elongation for fully annealed samples of 0.10 inch diameter and 0.5-inch gage length was 23 per cent; for the work-hardened material, 0.05-inch diameter and 0.5-gage length, 3 per cent.

Such figures for tensile strength and elongation are for metal containing appreciable oxygen and nitrogen. As purity of the metal improves, a considerable drop in tensile strength and increase in elongation may be expected. Vanadium is very susceptible to hydrogen embrittlement which can be removed by heating in vacuum to 400 deg Centigrade.

Corrosion tests have shown that vanadium is resistant to pitting and corrosion by sea water and salt spray. This resistance, in view of the metal's high elastic modulus and negligible magnetic susceptibility, might well lead to interesting applications in instruments and parts for dynamic stress on board ship or in salt water atmospheres.

Sans, Souci

Ad Libbing By the Editor

One day in June I was riding the train with Big Frank. We were going through the country where corn had been planted and was now about six inches high. Big Frank interrupted the silence with the remark, "You cannot see them from here but there are a lot of little weeds among that corn. Even when you stand close to it, some people cannot see them. But the farmer does, so he goes through the rows with his cultivator and stirs the ground. This buries the weeds and chokes them. If he didn't do that, the weeds would grow and soon would be higher than the corn and then the corn would be choked out."

Being an amateur farmer I nodded

and agreed with everything Big Frank had said. I knew he was leading up to something but I had not quite figured it out. After a few moments of silence Big Frank continued.

"It is that way in business too. You start a good business and it starts growing. But there are also weeds that start growing and if you don't take care of your business and get rid of the weeds the weeds will soon choke the business, and then you go bankrupt."

I thought that was quite a sage remark and I wasn't quite prepared for the closing one.

"With people it is the same thing," continued Frank, "they grow and they also have weeds growing and if they don't cultivate out the weeds they soon amount to nothing. We should always sit back and take stock of ourselves and look sharp for the weeds. They are just like the weeds in the farmer's field. At first they are so small you hardy can see them. But if you don't cultivate them out, they will soon choke you."

This was typical of the way Big Frank put across his philosophy. His homely little example of the weeds of the corn field speaks volumes. Big Frank could have also added that in all human organizations there are always weeds sprouting and if they are allowed to grow they soon take over and the organization, wherever it may be, declines and dies. This applies to individuals, families, schools, clubs, professional societies and—empires. A lot of weeds are flourishing in the U. S. A. just now. It is time they were cultivated out.

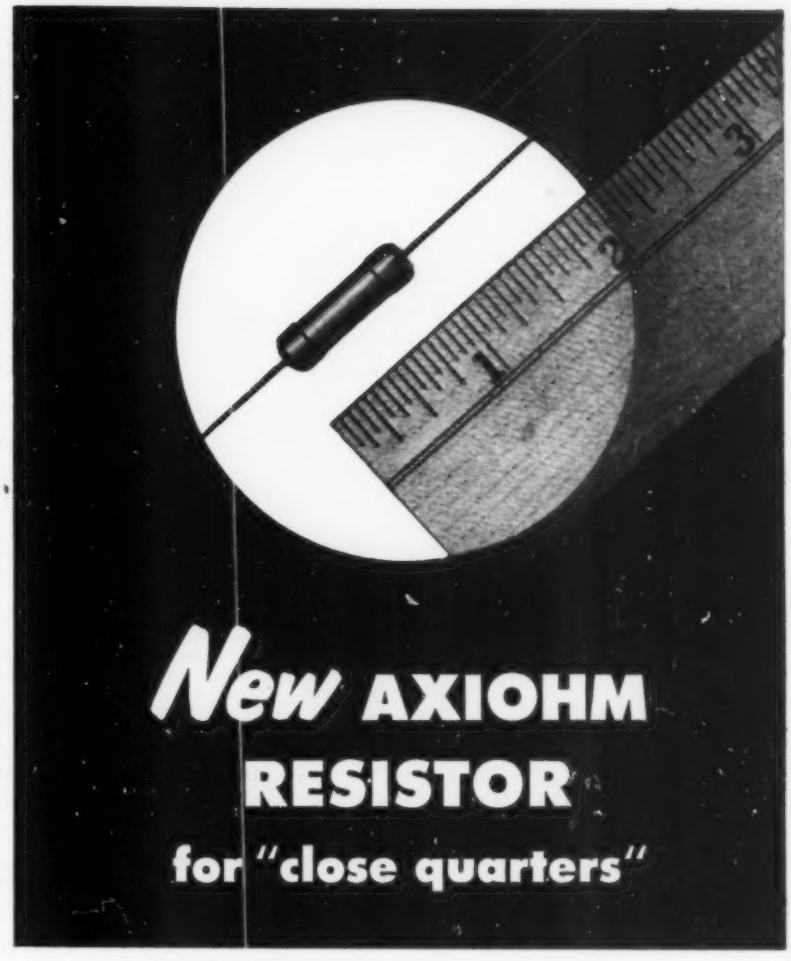
A Story in Three Pictures

In one of the offices of the General Motors Research departments hangs a framed display that tells a most impressive story. The "picture" does more than just tell a story; it teaches a great lesson.

The "picture" is nothing more than three advertisements which were clipped from some railroad magazine. The ads are presented exactly as they ran, without comment or alteration.

As I remember the display, the first ad, dated the early thirties, strongly declaimed that "Steam will always be the motive power of the railroads." That was the text and it was supported by resounding "ten dollar words" furnished by some bright young copy writer. Careful reading failed to show one bit of factual evidence or direct proof to support the sweeping claim. Typical of much advertising copy that lacks factual support, it was extremely fluent and emphatic.

Advertisement number two of the



Vitrohm enamel gives higher watt ratings

Save space...save time...use Ward Leonard's AXIOHM resistor.

No nuisance of lugs, screws, bolts. Axial leads are the only mounting support needed—easy to cut, shape and solder. Tough, too—can't come loose or pull apart.

Coating is Ward Leonard's famous *Vitrohm*. High heat dissipation—withstands thermal shock, vibration and corrosive atmosphere.

For "close quarters" applications, specify AXIOHM. Made in 5 and 10 watt sizes.

Write for Catalogue. WARD LEONARD ELECTRIC Co., 63 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WARD LEONARD ELECTRIC COMPANY

Result-Engineered Controls Since 1892

RESISTORS · RHEOSTATS · RELAYS · CONTROL DEVICES

prompt...
direct
delivery...
safely into
your
hands
PRP can deliver plastic moulded
parts directly to your door, geared to your production
schedule. Our fleet of trucks and private planes provides
this unique plus service which prevents shipping damage and
production hold-ups. Other PRP services include designing,
tooling, and production in small quantities, or in millions.
Telephone or write us about your problems.
Or, if you prefer, our plane will speed you
here to see our facilities and
discuss your problems.
When you look for plastic
mouldings, look first to
Plastic Research Products,
Urbana, Ohio
PRP

group of three was dated about five years later than number one. The subject was the same; the text was revised slightly to read "Diesel power has a limited field of use on the railroads but the main line freight and passenger trains will always be pulled by steam. We offer diesel locomotives for yard services. . . ." That's not exactly it, but it read something like that.

The final ad, dated almost ten years later, reluctantly announced that that company would no longer build steam locomotives. One can imagine the deep sorrow, the regrets and the fond memories that went into the writing of that last ad. Certainly no one could accuse that company of not trying hard enough to keep the steam locomotive in business. They allowed their heart to rule their head. That can sometimes look as silly as a deaf octogenarian suffering from halitosis, rheumatism and the seven-year itch trying to fox trot on the dance floor. The only thing wrong with him is that he is a little out-of-date—just about fifty years.

One Hundred Holes

The chief inspector and the super were having a hot argument over a jig to drill 100 holes in the periphery of a wheel. The chief said it wouldn't work because the jig located the holes from one to the next. The super claimed that the accuracy was such that the errors would about balance. Of course he was wrong, but when he drilled a scrap wheel it looked perfect. Gleefully he showed it to the inspector and challenged him to find anything wrong with the drilling.

The inspector called one of his men over, handed him the wheel and said: "Bert, find out what is wrong with the drilling."

About twenty minutes later Bert came back with his report. "As near as I can measure," he said, "the holes are spaced perfectly. But there are 101 holes instead of 100." Bert gave a sly grin.

In too many operations it is assumed without any basis whatsoever that errors will "average out." This cannot be true if the errors are inherently all plus or all minus. Also there is a vast difference between errors and mistakes. If the observer should jot down 50 when the reading is 150, the mistake or error of 100 will never "average out". In other words, sloppy work, slip shod methods, or basic mistakes can never "average out" into accurate results. Lots of people have gone far wrong in thinking so. —G. F. N.

WESTERN FELT:

Your Insurance Against Complaints

Felt is not "just felt." There is a vast difference in its manufacture and efficiency. Because Western Felt for over fifty years has not, and will not, depart from its policy of maintaining the highest possible quality in material and manufacture, its products, wherever they may be employed, are your insurance against product complaints due to a Western Felt component part.

Here are just a few of its features that you can always depend on: range from wool softness to rock hardness—never loses shape—does not ravel or fray—resists oil, water, heat, age, resilient, flexible, compressible—may be cut to extremely close tolerances for small parts—unsurpassed in uniformity.

Western Felt engineers with decades of experience in the use of felt stand ready to counsel you.

JUST A FEW USES:

- **Retaining lubricants**
- **Isolating vibration**
- **Controlling temperature**
- **Reducing weight**
- **Excluding dust, grit, etc.**
- **Cushioning shock**
- **Filtering liquids**
- **Grinding and polishing gaskets, grommets, etc.**
- **Padding, packing, sealing**

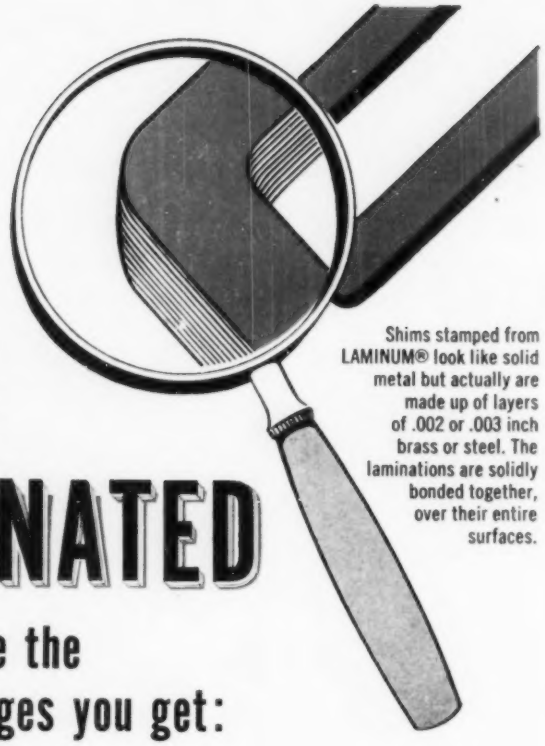
100F

WESTERN FELT WORKS

4035-4117 Ogden Ave., Chicago 23, Illinois

Branches in all Principal Cities

Largest Independent Manufacturers and Cutters of wool, hair and jute felts



Shims stamped from LAMINUM® look like solid metal but actually are made up of layers of .002 or .003 inch brass or steel. The laminations are solidly bonded together, over their entire surfaces.

when a shim is

LAMINATED

here are the advantages you get:

REDUCED MACHINING COST
You machine only to easy tolerances. The laminated shim is *adjustable*—you simply peel laminations of .002 inch brass or steel with a penknife—to get exactly the spacing you need. You cut costs without sacrificing quality.

SIMPLIFIED USE:
Shims come to you in one "pack" for each application. They are precision-stamped to your exact specifications. No counting, no stacking, no miking. Gauge is always known. No dirt or grit can lodge between layers.

SPEEDED PRODUCTION:
Final fitting can be done right at the job. You don't have to take parts back and forth for further machining, grinding or filing. No special skill required. The laminations adjust spacing quickly, easily.

ADDED SERVICE FEATURE:
Throughout the life of the machines you produce, the simple removal of a shim lamination provides a unique adjustment for the take-up of wear. Original clearances can always be restored.

SEND TODAY for our Engineering Data File

LAMINUM
THE SOLID SHIM THAT FOR ADJUSTMENT

LAMINATED SHIM COMPANY, INC.
1402 UNION STREET GLENBROOK, CONN.

CUSTOM SHIMS STAMPINGS SHIM STOCK

OUR READERS SAY

Too Thick Washer

To the Editor:

In the write-up in the December issue on the laminated washers of metal and neoprene composition, there are two corrections which we think should be made. The paragraph now reads: "Neoprene composition ranges in thickness from $1\frac{1}{16}$ to $\frac{1}{4}$ in. as specified. Standard thickness is $\frac{1}{16}$ to $\frac{3}{32}$ in.; for heavier than $\frac{3}{32}$ in. the tolerance is plus or minus $\frac{1}{64}$ in."

We recommend that this paragraph should be written as follows: "Neoprene composition ranges in thickness from $\frac{1}{16}$ in. to $\frac{1}{4}$ in. as specified. Standard thickness of neoprene composition is $\frac{1}{16}$ to $\frac{3}{32}$ in.; for heavier than $\frac{3}{32}$ in. thickness the tolerance is plus or minus $\frac{1}{64}$ in."

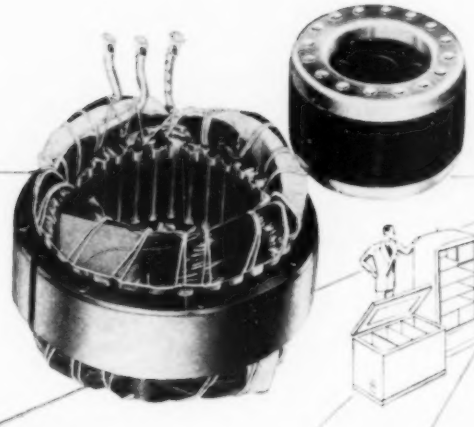
Also your sectional views of the washer are shown in an upside down position. The metal portion of the washer should always be on the top side. —P. J. JELLISON
Fabricated Products Co.

Ed—We stand corrected.

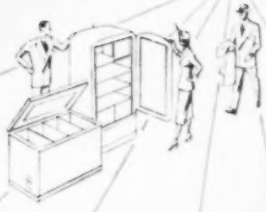
. . . "Materials Substitution" A Statement Corrected

To the Editor:

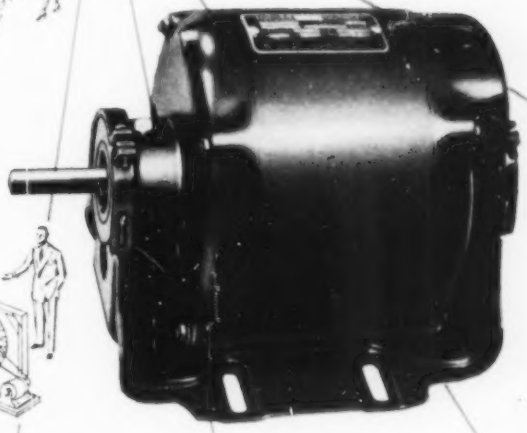
The October 1951 issue of PRODUCT ENGINEERING contained a splendid article on "How to Tackle Materials Substitution" which was distributed throughout the technical services of the Army for the information and guidance of those concerned with conservation of strategic and critical materials. However, the article included on page 123 the statement—"for example, the specifications on low-temperature impact properties of armor plate for the tank program require the use of steels with nickel content of four- to five-hundred percent greater than during the last war." This statement is incorrect. Actually, the low-alloy steel compositions developed for armor during World War II are being used today with few modifications. Changes in Military requirements have made it necessary to use some cast armor of greater thicknesses than any used on World War II tanks, and for such castings higher alloy content is

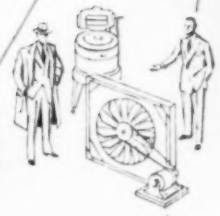


For **HIGH** starting torque . . .



Or **LOW** starting torque . . .





There's a

DELCO MOTOR

Built for the Job!

DELCO FEATURES MAKE DELCO FINEST

- Aluminum rotor conductors, end rings and fan blades.
- Oversize steel-backed tin babbitt sleeve bearings.
- Varnish-dipped and baked motor windings.
- Resilient rings of special oil-resistant material.
- Large oil reservoirs cast integrally with end-frames.
- Exclusive Delco Thermotron for automatic motor protection.

DELCO DAYTON OHIO

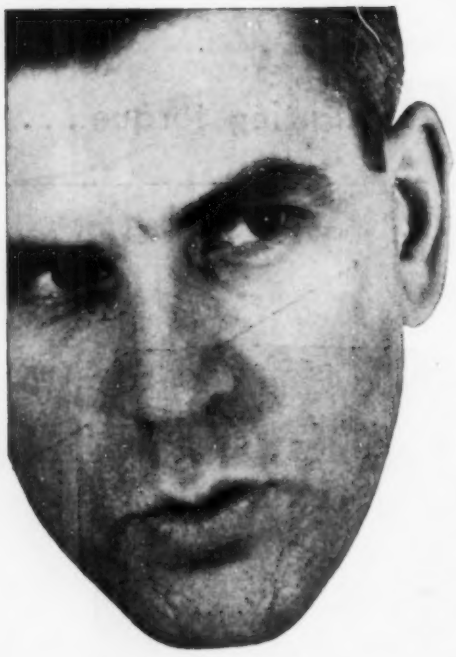
Yes . . . there's a fractional motor in the Delco line that's *engineered* to meet your requirements . . . and built to serve you and your product longer and better. That's true because the Delco line is a *complete* line, and every type of Delco motor has been *proved in use.*

Electrically and mechanically, Delco motors are made to deliver peak performance—continuously. Each part is precision made . . . and the motors assembled, inspected and tested to assure Delco dependability for the user.

Learn for yourself how Delco motors can serve you better. Call or write Delco Products, Dayton, Ohio, or the nearest sales office listed below.

DELCO PRODUCTS
Division of General Motors Corporation, Dayton, Ohio

SALES OFFICES: Atlanta • Chicago • Cincinnati • Cleveland • Dallas • Detroit • Hartford • Philadelphia • St. Louis • San Francisco



how much is bearing trouble affecting your products' reputation?

It can you know — and yet it is so easy to avoid machinery inefficiencies traceable to bearing failures. Just be sure to specify one of the MULTIROL full type roller bearing series. Each is designed for a specific kind of service and has proven ability to carry greater loads longer with more precision and less maintenance. Their dependability will help keep your machinery at its peak. Select one of the following types and write today for more details in the new McGill Bearing Catalog No. 52.

required. On the other hand some producers actually have been able to reduce nickel through improved practice while successfully meeting the specified low-temperature impact requirements.

As you may know, the Ordnance Corps does not specify the kind or percentage of alloys in steel armor but leaves the producer free to select the composition best suited to his practice and conditions. Throughout World War II Ordnance agencies, particularly Watertown Arsenal, Aberdeen Proving Ground and OCO-Detroit (now Detroit Arsenal) cooperated closely with industry to reduce the amount of critical alloys in armor. As a result the average alloy content of armor produced during 1942-1945 was approximately one-half that used in 1940-1941. Through continued Industry-Ordnance cooperation the current specifications, including the requirements for low-temperature impact, were developed and, by actual test and experience, it has been determined that those requirements generally can be met without increasing alloy content by the use of good heat-treating practice and controls. Now as in World War II some armor producers use no nickel while others find it necessary or desirable to include that alloying element, to some extent.

The Ordnance Corps in cooperation with armor producers is continuing research and development work aimed at the further conservation of strategic and critical alloys in armor to the maximum extent practicable without sacrificing protection.

—LESLIE E. SIMON
Brigadier General, USA
Assistant Chief of Ordnance

Ed—Evidently, we were far off base on this item. Your letter will correct any wrong impression that might have been created by that erroneous statement. We received that information from what was presumably good authority.

Comment On Computers

To the Editor:

Your November issue in general, and your computer article by Franz Alt in particular, were very interesting. Here are some comments on that article:

1. In the table on page 148, the average time for multiplication by the ERA Computer was given as 1 to 68 milliseconds. For the ERA 1101 Computer this time of estimate is excessive.

Under optimum conditions, the ERA

GITS Unit* SEAL
Now STANDARDIZED

For . . .

Gear Reduction Units
Aircraft Reciprocating Engines
Automotive Accessories
Jet Propulsion Units
Washing Machines
Standard & Special Machine Tools
Electrical Power Equipment
Business Machines

If *you* have a shaft sealing problem, Gits experience in these and many other specific applications can prove of great and immediate value to you.

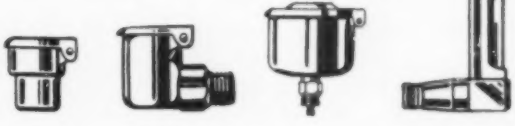
Write today for FREE illustrated Brochure, or send us your seal problem.

*Cartridge Seal . . . pressure balanced . . . requiring only 25% more space than lip-type seals.

GITS BROS. MFG. CO.

1838 S. Kilbourn Ave. • Chicago 23, Ill.

Gits Lubricating Devices,
The Standard For Industry For Over 40 Years

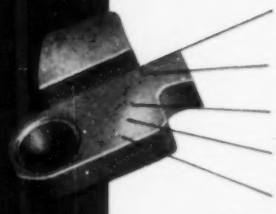


Microcast®

Slashes Cost

Assembly of 6 Parts Cut to 2 Integral Parts

CLUTCH STOP PAWL



Microcast as 1 piece; formerly 4 piece assembly.

Used as cast, except for drilling and reaming one hole.

Sound structure — dimensionally uniform.

Milling operation and assembly eliminated.

Microcast reduced cost on this part 20%.

DRUM LOCK PAWL

Microcast as 1 piece; formerly 2 piece assembly.

Used as cast, except for drilling and reaming one hole.

Special form cutters, gages, jigs, etc. eliminated.

Milling operation and assembly eliminated.

Microcast reduced cost on this part 75%.

MICROCAST PRECISION CASTINGS PROCESS

MICROCAST offers design engineers many opportunities for product improvement of small components with substantial savings in cost. High melting point, non-machineable, non-forgeable alloys can be specified for economical quantity production, too. Write for complete information.

MICROCAST DIVISION
AUSTENAL LABORATORIES, INC.
224 East 39th St., New York 16, New York
715 East 69th Place, Chicago 37, Illinois

FREE BOOKLET

Get your copy of this all-inclusive 16-page booklet on Microcastings. Write today!

MICROCAST

1101 Computer multiplies in 0.5 milliseconds. Under random conditions, the average time to get both the multiplier and multiplicand from storage, multiply, and read the next order, would be about 32 milliseconds.

The actual average time for a multiplication depends upon the program of computations performed and the skill of the programer who directs the computer to carry them out. Careful arrangement in the storage system of the number to be multiplied will keep the time close to the 0.5 millisecond minimum. When a program of computations is not carried out often enough to justify this careful arrangement of the storage system, a skilled programer can sometimes divide it into frequently used sub-programs. Therefore, the average multiplication time can vary by a factor of about 60 which depends upon the nature of the computation and the skill of the programer.

2. Reliability of operation is a very important factor in the evaluation of automatic computing machines. As electronic components age, their operation is less stable. The ERA 1101 Computer contains many features to compensate for this. The result is very little unscheduled maintenance since operation began late in 1950.

—FRANKLIN H. FOWLER, JR.
Engineering Research Associates, Inc.

Slide Rule Short Cuts

To the Editor:

I have noticed, through this past year, that you have published several letters in your column on short-cuts with a slide-rule. I would like to add the three tables below as I have found them of great use and also little known amongst the general run of slide-rule users.

Solution of Quadratics.

The method used is one factorisation and in order to use it the equation must be put in the form $x^2 + bx + c = 0$. The index of the *C* scale is placed over the value of '*c*' on the *D* scale. The cursor hairline will now give two factors of '*c*', one on the *D* scale and the other on the reciprocal or C_1 scale.

The hairline is now moved so that the sum or difference of these two factors (depending on the signs in the equation) equals the coefficient '*b*' These factors are then the required roots of the equation.

Solution of Cubics

Cubics can be solved by a similar technique if they can be reduced to the form $x^2 + b/x = a$.

Set the slide index to '*b*' on the *D* scale. Move the hairline to any '*x*' on

Ever See a Car **Without Fasteners?**

APPROXIMATELY 2½% OF THE STEEL PRODUCED IS USED TO FASTEN THE REST TOGETHER!

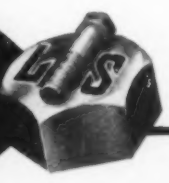
Like so many important little things in our every day life, people are apt to take glamorless bolts and nuts for granted. But it takes only a second to realize what a tremendous contribution they make to our way of living.

The importance of fasteners is fully realized by the designers, the engineers, production men and top executives of industry. And they know, too, that Lamson & Sessions is their most reliable source of supply—with one of the most complete fastener lines of any manufacturer.

Look to Lamson for progress in fasteners. We welcome your inquiry on *any* fastener problem.

The home of "quality controlled" fasteners

Lamson + Sessions



The **LAMSON & SESSIONS** *Co.* • • General Offices: 1982 West 85th Street • Cleveland 2, Ohio

Plants at Cleveland and Kent, Ohio • Birmingham • Chicago

THOMAS
Flexible ALL METAL
COUPLINGS
FOR POWER TRANSMISSION
REQUIRE NO MAINTENANCE

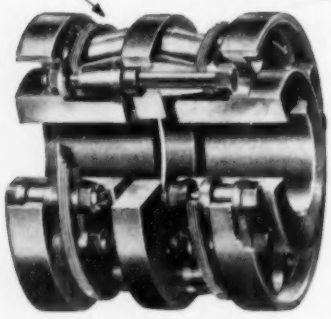
Patented Flexible Disc Rings of special steel transmit the power and provide for misalignment and end float.

Thomas Couplings have a wide range of speeds, horsepower and shaft sizes:
½ to 40,000 HP
1 to 30,000 RPM

Specialists on Couplings for more than 30 years

BACKLASH
FRICTION
WEAR and
CROSS-PULL
are eliminated
Lubrication is not required!

PATENTED FLEXIBLE DISCS



THE THOMAS PRINCIPLE GUARANTEES PERFECT BALANCE UNDER ALL CONDITIONS OF MISALIGNMENT.
NO MAINTENANCE PROBLEMS.
ALL PARTS ARE SOLIDLY BOLTED TOGETHER.

Write for the latest reprint of our Engineering Catalog.

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA

the D scale. On $C1$ will be the value of b/x and on the A scale will be x^2. If the sum of these two values is equal to 'a' the chosen value of 'x' is a root of the equation. Two roots can be found in this manner and the third is obtained from $x_1 + x_2 + x_3 = O$.

Ratio $(n/n')^3$

This ratio is often encountered, as when pump test results have to be corrected to constant speed. Set $n' + (n'-n)$ on the C scale over $n-(n'-n)$ on the D scale. The index gives the ratio $(n/n')^3$.

For example for a pump test, curve to be drawn for 2,000 rpm.

Power taken at 2,100 rpm = 40 hp

Set 2,200 over 1,900

Read hp for 2,000 rpm under 40 on the C scale = 34.554

The true result is 34.554, and error of only 0.03 percent. Incidentally even if n and n' vary by as much as 25 percent the error incurred is only 2 percent.

—P. PEMBERTON-PEGOTT
Hydro Electric Power Commission of Ontario
Toronto, Ontario, Canada

A New Style Engine

To the Editor:

I have (what I call) an idea, not an invention, for a new type of engine which can be used with gasoline or diesel fuel. The method of its construction has not been adopted by any concern.

The advantages over present engines are: no stress on connecting rods or crankshafts since these will exert very little movement and consequently little wear; elimination of the tendency of the piston to go sideways as wear increases; crankshaft made in a straight line; and one or two connecting rods will drive any two or more cylinder engine—the rods not exerting force through the pistons.

I can submit rough sketches of this idea, and I am very anxious to contact interested parties who have the facilities for casting new engine blocks and testing them. However I wish to be protected and to be able to enjoy a share of profit whenever this new engine is produced and put on the market.

Could you suggest what people in the United States I might contact?

—EDWARD VINCENTI
Richard Kind Auto Sales Co., Ltd.
Malta, Europe

Ed—Most American industrial concerns will not talk to an outside inventor until he can come to them with a

Wherever it's
HOT
specify
Sicon

NEW IMPROVED SILICONE-BASE HEAT-RESISTANT FINISH

Protects Stewart Warner's New Saf-Aire Wall Furnace

Quality finish specifications for this heating unit called for a coating that would stand 500° and still retain its color and gloss—a temperature far above that incurred in normal operation. Ordinary heat resistant coatings failed. SICON *Ivory* and SICON *Beige* worked perfectly...just as SICON has solved so many other finish problems. *Write for dynamic proof of SICON'S amazing stability under heat! New Brochure now ready.*

Sicon
Silicone-Base Finish is manufactured exclusively by
MIDLAND
INDUSTRIAL FINISHES CO.
Waukegan, Illinois
ENAMELS · SYNTHETICS
LACQUERS · VARNISHES

Aeroquip

REG. TRADE MARK

FLEXIBLE HOSE LINES

WITH DETACHABLE,
REUSABLE FITTINGS

- PREVENT LEAKAGE
- ARE RESISTANT TO FIRE
- HELP REDUCE OPERATING COSTS
- ELIMINATE FAILURES DUE TO VIBRATION
- OPERATE AT —40° TO +275° F. TEMPERATURES
- FOR USE WITH HYDRAULIC FLUIDS, WATER, FUEL, LUBRICATING OILS AND MANY OTHER FLUIDS

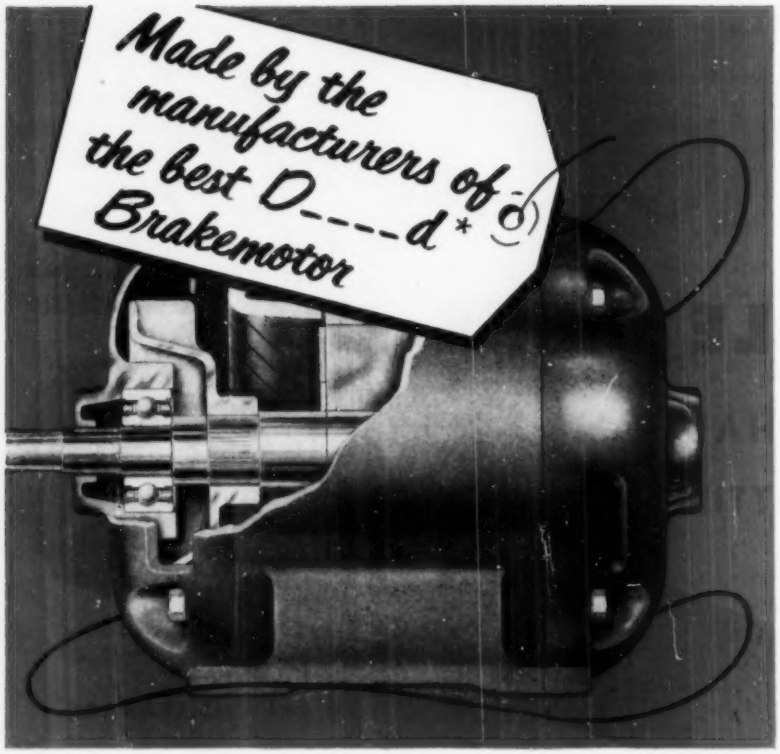
Aeroquip for better performance, maintenance and service

AEROQUIP CORPORATION

JACKSON, MICHIGAN

SALES OFFICES: BURBANK, CALIF. • DAYTON, OHIO • HAGERSTOWN, MD. • HIGH POINT, N. C. • MIAMI SPRINGS, FLA. MINNEAPOLIS, MINN. • PORTLAND, ORE. • WICHITA, KAN. • TORONTO, CANADA

AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD



YOU GET THESE 5 ADVANTAGES
when you use Star-Kimble Squirrel-Cage Motors

1. *Sturdy construction.* Frames through NEMA 364 are of rigid cast construction, with more internal ribs than are used in conventional design, giving added strength and better heat dissipation. Larger frames are made of steel.
2. *Simplified maintenance.* Double-width cartridge bearings are prelubricated—need no attention for many years.
3. *Versatility of mounting.* Standard NEMA horizontal, D Flange, C Face, P Ring. Motors through frame 320 can be made dripproof in any mounting position—simply by rotating end shields.
4. *Extra insulation.* Safety factor is provided for possible rises above rated temperature—motor life is lengthened, maintenance reduced.
5. *Simplified design.* Lines are smooth, with no dust- and dirt-catching crevices. Fewer basic parts—greater interchangeability. Basic parts stocked for immediate shipment.

Star-Kimble Squirrel-Cage Motors are available in NEMA frames 203-505, and in NEMA Designs "B", "C" and "D." Also in larger sizes. Write for Bulletin B-201.

*Demanded by industry for tough start-and-stop jobs

STAR-KIMBLE
MOTOR DIVISION OF
MIEHLE PRINTING PRESS AND MFG. CO.
211 Bloomfield Avenue Bloomfield, New Jersey

patented device. This practice is followed to protect the company against subsequent claims of appropriating the invention and possible lawsuits. We would suggest as your first step that you secure patent protection on your engine and then submit it to one of the companies in this country interested in the manufacture of gasoline or diesel engines. In fact, once you've obtained patent protection we'd be interested in discussing your engine in the editorial pages of PRODUCT ENGINEERING.

Army Orders

To the Editor:

Reference is made to our letter dated 31 October 1951 regarding the availability and price of a reprint of an article entitled, "Our Next Major Metal, Titanium," which appeared in an issue of PRODUCT ENGINEERING.

Since it is the policy of this installation to issue an official government purchase order in advance for reprints and other library materials, we are returning herewith the paper on titanium metal which was received in reply to the above letter. You will no doubt receive a purchase order for this paper at some future date.

We appreciate your attention and cooperation in this matter and regret the trouble our request may have caused you. —FRANK M. MARSON
Engineer Research and Development Lab.
Fort Belvoir, Va.

Ed—??????

Help For Study Program

To the Editor:

At Clarkson College of Technology I am conducting a course in Engineering Materials and Manufacturing. The course is a year and a half in duration and a comprehensive examination terminates the work. This year I would like to ask questions concerning engineering materials and manufacturing based on the advertisements of a technical journal.

For several years I have subscribed to PRODUCT ENGINEERING and I feel that this magazine would be excellent for the above plan. Would it be possible to send us 42 complimentary copies of a recent issue for this purpose? The copies would be distributed to the students for their final examination in the course, and then returned to the college for use next year.

We appreciate your efforts on our behalf and hope that it will be possible

for you to work with us on this plan.
—MYRON G. MOCHEL, ASSOC. PROFESSOR
Clarkson College of Technology

Ed—Digging up forty-two complimentary copies of a recent issue of PRODUCT ENGINEERING turned out to be quite a chore. We finally managed to find that number of the June issue and we have sent them to you. We are glad to cooperate with you on your study program.

There Are Steels and Steels

To the Editor:

We are interested in obtaining information on the use of tool steel tubing, sold by many firms for making bushings, die sets, blanking and forming dies, and various types of machine parts, such as sleeve and collet bushings. This material is furnished to the user in the annealed state.

Many advantages are said to result from the use of this stock. These claims however, are all very general in nature, and we are investigating the economics of its applications. How much of this material is used? What real savings can be obtained through its use? Where, when and how is it used?

Have you published anything on this subject in recent years? Can you put us in touch with or suggest any persons whom we can contact to get more information on this subject?

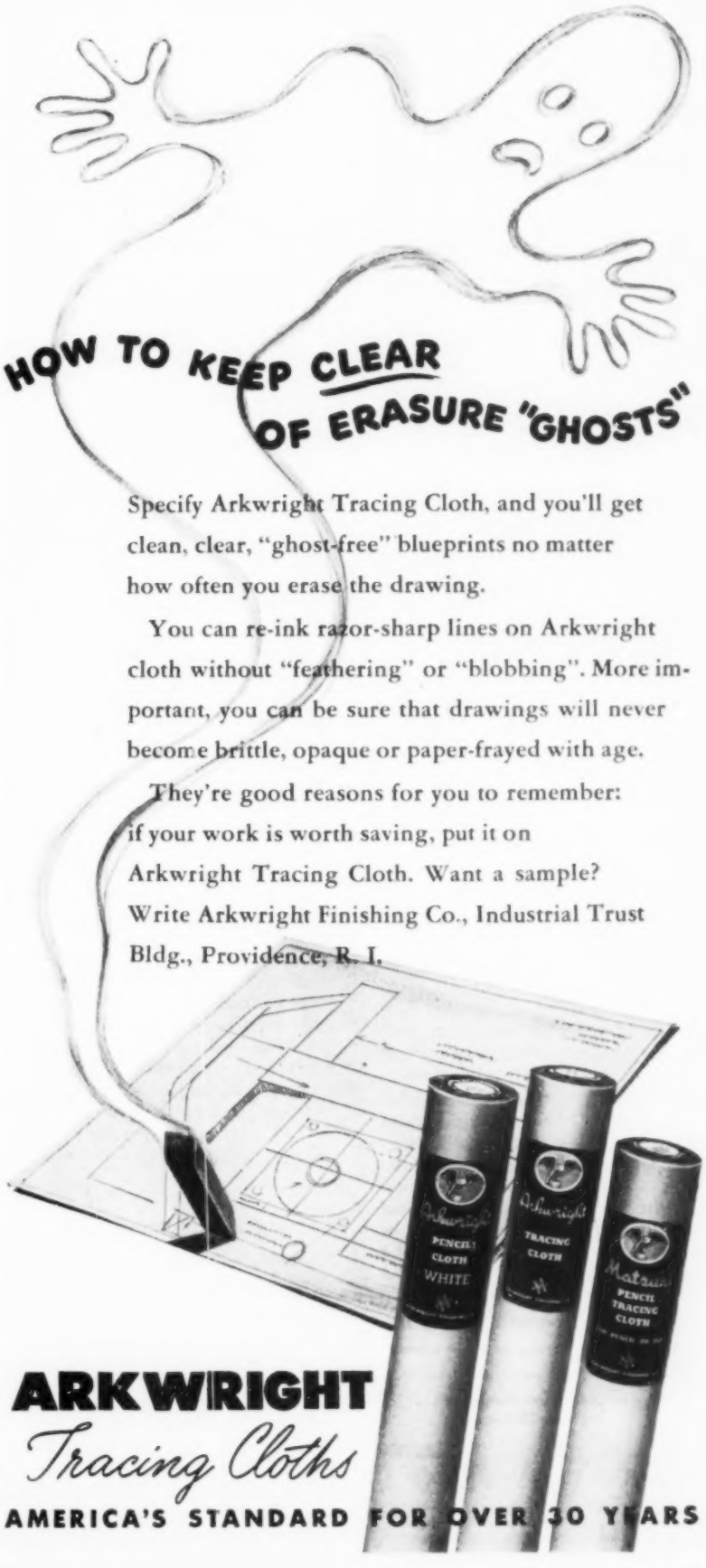
—FRANK W. HANKINS
Frank W. Hankins & Co., Inc.

Ed—Some of these questions we can answer but there is no adequate answer for some of them. The American Iron and Steel Institute may be able to give you additional information on production figures.

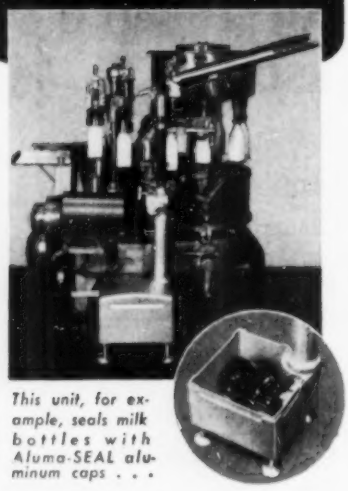
According to the U.S. Census of manufactures for 1947, production of alloy steel tubing was 201,986 tons with a dollar volume of $36,611,000.

The question of economies to be obtained through the use of a tool steel depends on the service conditions under which the tool or part is to operate. Naturally the higher the alloy content the more expensive the steel. In addition, higher alloy steels are more difficult to work. A designer never uses a high alloy steel where a low carbon steel will do the job.

Where elevated working temperatures are involved or where wear resistance is essential, it is some times impossible to use anything but high alloy steels. In some cases special techniques, such as cold-working, can improve the strength of materials to


HOW TO KEEP CLEAR
OF ERASURE "GHOSTS"
Specify Arkwright Tracing Cloth, and you'll get clean, clear, "ghost-free" blueprints no matter how often you erase the drawing.
You can re-ink razor-sharp lines on Arkwright cloth without "feathering" or "blobbing". More important, you can be sure that drawings will never become brittle, opaque or paper-frayed with age.
They're good reasons for you to remember: if your work is worth saving, put it on Arkwright Tracing Cloth. Want a sample? Write Arkwright Finishing Co., Industrial Trust Bldg., Providence, R. I.
PENCIL CLOTH WHITE
TRACING CLOTH
PENCIL TRACING CLOTH
ARKWRIGHT
Tracing Cloths
AMERICA'S STANDARD FOR OVER 30 YEARS

how to FEED MATERIALS ECONOMICALLY: use GAST rotary AIR PUMPS!



This unit, for example, seals milk bottles with Aluma-SEAL aluminum caps . . .

PROBLEM: Remove caps *one-at-a-time* from magazine, and hold ready to drop into feed chute.

SOLUTION: Suction cup with 20" to 22" vacuum, produced by positive-action Gast Rotary Air Pump.

RESULT: Dependable, low-cost operation from portable Gast unit in housing on floor.

Just for a moment, consider how you could apply low vacuum for feeding sheet materials and small parts of paper, fibre, plastic or light metal.

The possibilities are enormous for extra speed — extra savings — extra safety. And Gast Rotaries are giving excellent service on scores of common — and unusual — applications.

When you have problems that might be solved with low vacuum or pressure, write Gast. "Air may be your Answer!"

SEE OUR CATALOG IN SWEET'S FILE

Gast Application Ideas Booklet — showing 26 design problems solved — sent upon request.

Original Equipment Manufacturers for Over 25 Years

GAST ROTARY

AIR MOTORS · COMPRESSORS · VACUUM PUMPS

(TO THREE H.P.) (TO 30 LBS.) (TO 28 INCHES)

GAST MANUFACTURING CORP., 139 Hinkley St., Benton Harbor, Mich.

such an extent that a lower priced steel so worked can do the job of one of higher alloy content. In June PRODUCT ENGINEERING (page 130) there is an article entitled "Selecting the Proper Steel" which discusses these factors in detail.

In some cases, as in die bushings, for long runs it may be more economical to use a tungsten-carbide instead of even the hardest steel. However, without knowing in detail the operating requirements of a part, it is impossible to pick the best material.

Drafting Standards

To the Editor:

In the July 1951 issue of PRODUCT ENGINEERING we noticed an article titled "Engineering Checkers Promote Economical Production" by George E. Rowbotham, Standard Engineer Consultant.

In this article "Company Engineering Drafting Standards" was mentioned. We would like to know if there exists a publication with this name, and if so where we could buy it and at what price —ERIC CAULEY
Aktiebolaget Elektrolux
Stockholm 12, Sweden

Ed—In the article "Engineering Checkers Promote Economical Production" the reference to "Company Engineering Drafting Standards" was intended to refer to the drafting standards which most companies have set up for themselves to avoid error in interpreting drawings.

In this country there have been a number of attempts to set up industry wide drafting standards, but none of them completely successful. Particular industries such as aircraft manufacturers and automobile builders have pretty much standardized the symbols to be used in drawings relating to their products. In other segments of the industry, however, this is not true.

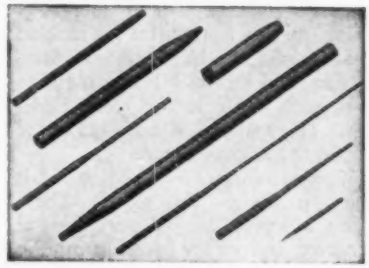
Starting A Reference File

To the Editor:

We are interested in revising our system of finishes on products which we manufacture. We would like to establish a relatively inexpensive reference means which can be used by the Production Department and the Inspection Department.

We have issues of PRODUCT ENGINEERING dated from January, 1940, to the present date. Will you please inform us which issue or issues contain information on systems of finish desig-

YOU SAVE on parts made to your specifications by TORRINGTON



You save time and money when you rely on our high productive capacity and special equipment to turn out precision parts to your order.

Typical are surgical and dental instruments, pen and pencil barrels, soldering iron cases, etc. Medium wall tubing up to 2½" O.D. and solid steel .015" to ¾" diameter handled.

We are also set up to make such parts as special rollers, shafts, studs, dowel pins, special needles, instrument shafts and pivots, screw driver and ice pick blades, knurled mandrels and spindles, etc.

Send your prints and specifications today for prompt quotation.

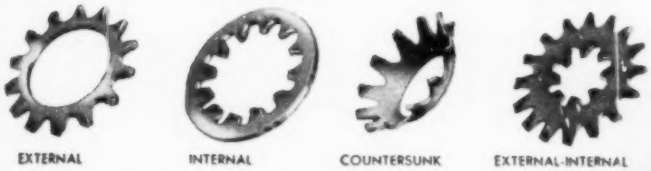
THE TORRINGTON COMPANY
Specialty Department
554 Field Street • Torrington, Conn.

Makers of
TORRINGTON NEEDLE BEARINGS

BUILD THEM BETTER

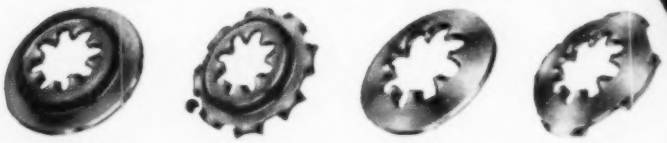
WITH SHAKEPROOF® Lock Washers

Multiple tapered-twisted teeth bite deeply to resist vibration loosening—lock even tighter as vibration increases!



EXTERNAL | INTERNAL | COUNTERSUNK | EXTERNAL-INTERNAL

A size and type to meet your specific fastening need!



DOME PLAIN PERIPHERY | DOME TOOTHED PERIPHERY | DISHED PLAIN PERIPHERY | DISHED TOOTHED PERIPHERY

SEND FOR FREE SAMPLE KIT, TODAY!

Make your own tests . . . see how every fastening can be positively locked against the hazard of vibration loosening. Ask for Sample Kit No. 21.

KEPS | SEMS

For maximum manufacturing efficiency, SHAKEPROOF Lock Washers are available pre-assembled to screws (SEMS) or nuts (KEPS).

SHAKEPROOF Inc.

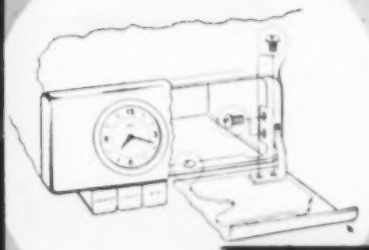
"Fastening Headquarters"

T.M. REG. U.S. PAT. OFF.

DIVISION OF ILLINOIS TOOL WORKS

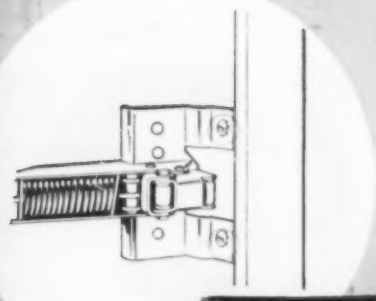
St. Charles Road, Elgin, Illinois

In Canada, Canada Illinois Tools Ltd., Toronto, Ont.



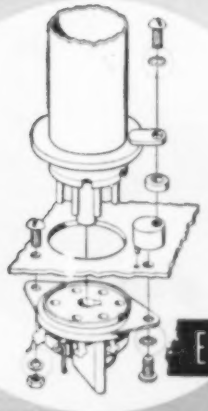
AUTOMOBILES

Here SHAKEPROOF Lock Washers are used to lock glove compartment assembly fastenings tight . . . positive protection against vibration loosening and the abuse of frequent slamming.



REFRIGERATORS

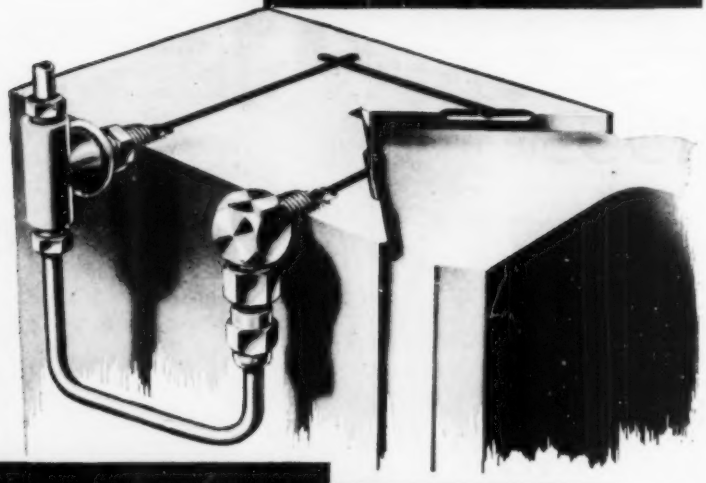
This refrigerator door latch mechanism is carefully adjusted for proper closing action. SHAKEPROOF Lock Washers hold the fastenings tight and prevent shifting of the assembly in service.



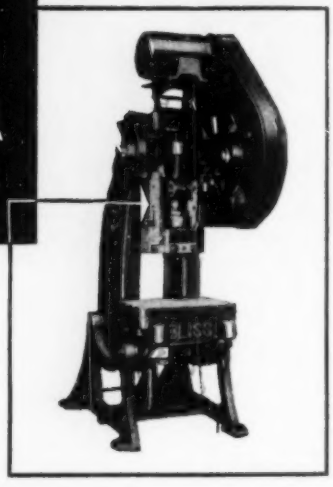
ELECTRONICS

This application is typical of the extensive use of SHAKEPROOF Lock Washers in electrical and electronic assemblies of all kinds, protecting vital fastenings against loosening and assuring efficient electrical grounding.

How to LUBRICATE A VERTICAL V SLIDE



. . . the way BLISS does it with a BIJUR SYSTEM



Above cross-section thru gibs of Bliss Inclinable Press No. 218 at point of lubrication, with slide lowered below actual position to show details.

The problem here was to keep a film of oil between the gib and slide contact surfaces. It is solved by drilling thru the gibs to grooves . . . controlling the oil flow thru meter-units at the gibs . . . supplying a measured volume of oil from an automatic lubricator which force-feeds oil to the seven press bearings. This is another example of Bijur "team-work for bearing protection." For aid in solving your lubrication problems, call in a Bijur engineer.

851

BIJUR

LUBRICATING CORPORATION

Rochelle Park • New Jersey

nations covering the range from the coarsest to reasonably fine finishes.

—CHESTER FANSHIER, PRES.
Metal Goods Mfg. Co.

Ed—Your best bet for that information is the PRODUCT ENGINEERING Annual Index which appears in the December issue each year. You will find a classification covering articles that appeared throughout the year on coatings and finishes.

One Reason For Pictures

To the Editor:

In an article by M. Goldstein, on electronic controls, page 191 of the November issue, I noticed a reference to a mounting board type of terminal strip illustrated by Figure 2 on page 192. Will you please send me information as to the manufacturer of this item so that I may write for purchasing information? I am interested also in the over and under block shown in Figure 3.

—R. S. CONABEE
Pacontrol

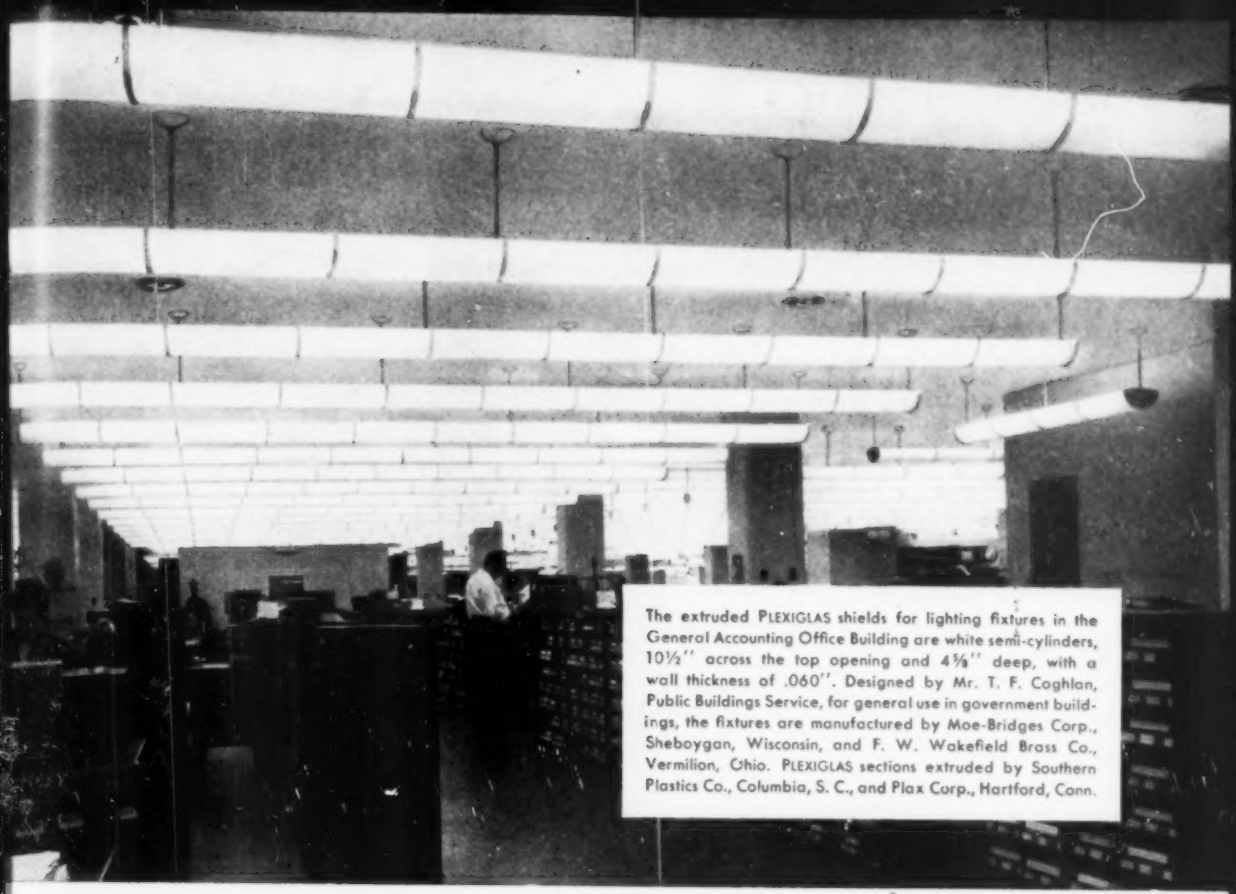
Ed—All of the equipment illustrated in this article was manufactured by the General Electric Company. We would suggest that you get in touch with your local office of GE, who will be able to give you full information about it.

ERRATA

Oct., 1951 Page 126. *How to Tackle Materials Substitution.* The statement ". . . for example, the specifications on low temperature impact properties of armor plate for the tank program requires the use of steels with nickel content of four- to five-hundred percent greater than during the last war . . ." is incorrect. Low alloy steel compositions developed for armor during World War II are being used today with few modifications.

Nov., 1951 Page 144. *Preplasticizer Triples Capacity of Molding Press.* The credit line under the cutaway drawing of the Watson-Stillman press was inadvertently omitted. This illustration was supplied through the courtesy of the Socony Vacuum Oil Company.

Dec., 1951 Page 222. *Laminated Washer of Metal and Neoprene.* Sentence ". . . Neoprene composition ranges in thickness from $1\frac{1}{16}$ in. to $\frac{1}{4}$ in., as specified . . ." should read ". . . Neoprene composition ranges in thickness from $\frac{1}{16}$ in. to $\frac{1}{4}$ in., as specified. . ."



The extruded PLEXIGLAS shields for lighting fixtures in the General Accounting Office Building are white semi-cylinders, 10½" across the top opening and 4⅝" deep, with a wall thickness of .060". Designed by Mr. T. F. Coghlan, Public Buildings Service, for general use in government buildings, the fixtures are manufactured by Moe-Bridges Corp., Sheboygan, Wisconsin, and F. W. Wakefield Brass Co., Vermilion, Ohio. PLEXIGLAS sections extruded by Southern Plastics Co., Columbia, S. C., and Plax Corp., Hartford, Conn.

25 Miles of EXTRUDED PLEXIGLAS

At the new General Accounting Office Building in Washington, twenty-five miles of PLEXIGLAS acrylic plastic shields are used to reflect and transmit light from nearly thirty-three thousand fluorescent fixtures. Extrusion-grade PLEXIGLAS made possible the most economical production of shields that would meet the rigid requirements of the application — dimensional stability, resistance to discoloration and breakage, and control of the transmittance-reflectance ratio.

For *your* large volume applications requiring extruded parts, consider PLEXIGLAS. Extrusion-grade PLEXIGLAS molding powders are being used for a wide variety of shapes—curved panels, tubes, rods, and flat and corrugated sheets. Such sections have the familiar PLEXIGLAS properties of light weight, durability, dimensional and color stability, and resistance to age and weather.

For information on clear and colored PLEXIGLAS powders for injection and extrusion molding, write for our technical bulletins. We'll be glad to send you full details.

CHEMICALS FOR INDUSTRY

ROHM & HAAS COMPANY

WASHINGTON SQUARE, PHILADELPHIA 5, PA.

Representatives in principal foreign countries

PLEXIGLAS *is a trade-mark, Reg. U. S. Pat. Off. and in principal foreign countries.*

Canadian Distributor: *Crystal Glass & Plastics, Ltd., 130 Queen's Quay at Jarvis Street, Toronto, Ontario, Canada.*

CAN *You* USE THESE UNITS

...OR THE SKILL THAT BUILT THEM

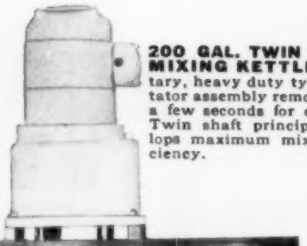
NOTE WIDE RANGE VERSATILITY APPARENT IN LARGE AND SMALL KETTLES SHOWN

● Do your productions call for pressure kettles or processing machinery in Stainless Steel, Nickel, Monel, Everdur, Inconel? Do they require strict sanitation in the units ... high speed heating super-efficient mixing, blending, homogenizing?

● If so, count on GROEN for competent counsel, proficient engineering, fast production. Building such units, large and small, has been our specialty for 50 years. That is why we've become today's largest producers of such equipment ... with ample facilities, experience and financial solidarity to handle your requirements promptly and efficiently. And we're prepared to work to your roughest specifications or to create special units to solve your individual problem.

TABLE TYPE VACUUM TILTING KETTLE. A typical example of GROEN engineering. Supplied as autoclave and/or equipped with various types of agitators.

● So, if components of equipment on your Defense orders or regular production require equipment in this category, call confidently on GROEN. Write our Engineering Dept. now about your present or anticipated requirements.



200 GAL. TWIN SHAFT MIXING KETTLE. Sanitary, heavy duty type. Agitator assembly removable in a few seconds for cleaning. Twin shaft principle develops maximum mixing efficiency.

GROEN MFG. CO.
4535 W. Armitage Ave.
CHICAGO 39

30 Church Street
New York 7

7 Front Street
San Francisco 11

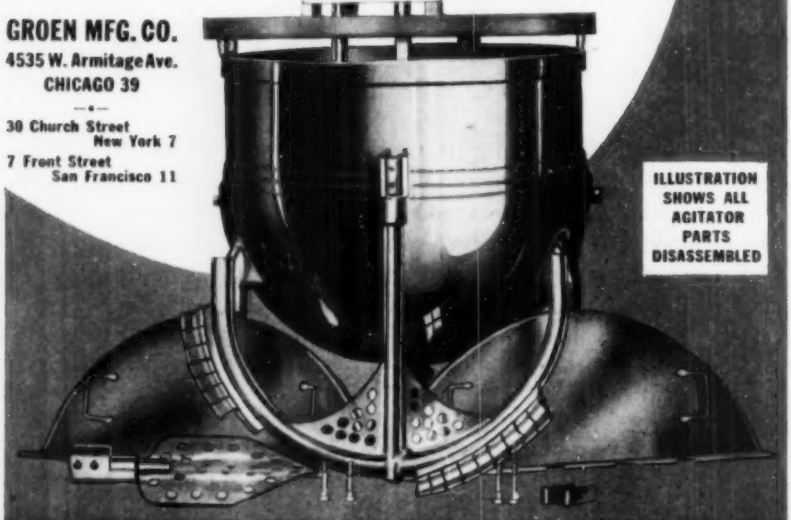


ILLUSTRATION SHOWS ALL AGITATOR PARTS DISASSEMBLED

WORLD'S LARGEST PRODUCERS OF

Half a Century of Fine Kettles

GROEN

STAINLESS STEEL STEAM JACKETED KETTLES

NEW BOOKS

Alternating-Current Machines

GEORGE V. MUELLER, *Professor of Electrical Engineering, Purdue University, registered professional engineer. 502 pages, 6 x 9 in. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N. Y. $7.50.*

Intended primarily for use by senior electrical engineering students, this new text presents an analysis of the construction and operating principles of transformers, polyphase induction machines, synchronous machines, single phase motors, and rectifiers.

An unusual number of problems and oscillograms are included which are used to illustrate analytically and graphically the principles being discussed. Recent applications of high frequency induction motors and rectifiers are covered. The treatment is practical with a design viewpoint. Standard symbols and abbreviations are used throughout.

Exceptionally clear in presentation, this text offers a superior treatment of the subject in approach, arrangement and method of treatment, and ease of understanding.

The text includes chapters on Special Types of Transformers, Transformer Connections in Polyphase Systems, Polyphase Induction Motors, Speed Control of Induction Motors, further Induction Machine Topics, Synchronous Generators, Synchronous Motors, and Single-phase Motors.

Positive-Displacement Pumps And Fluid Motors

WARREN E. WILSON, *president, South Dakota School of Mines and Technology. 250 pages, index included, 6 x 9 in. Published by Pitman Publishing Corp., 2 W. 45th St., New York, N. Y. Hard Cover, $7.50.*

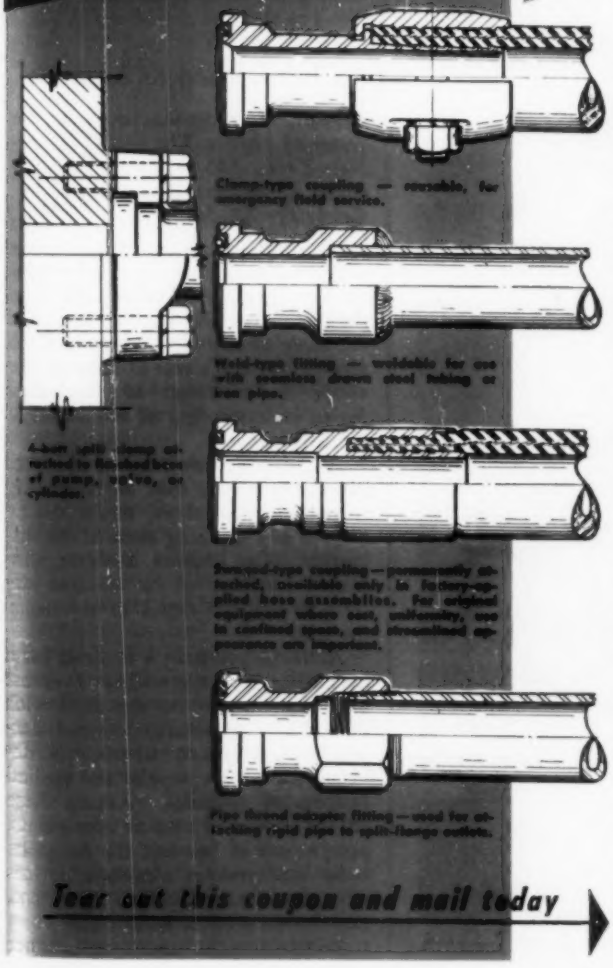
Here is offered an explanation of the physical principles on which positive displacement hydraulic pumps and motors operate, a description of the various types of pumps and motors in common use, and an introduction to the factors that must be considered if this equipment is to be wisely applied.

After an elementary discussion that includes formulas and diagrams, defines Pascals law of fluid mechanics and the reasons for deviation from ideal performance of hydraulic machines are explained, the pumps and motors in common use are divided into

Stop Leaks... Eliminate Threaded Joints

in hydraulic hose assemblies

with this revolutionary, easy-to-use ANCHOR SPLIT-FLANGE CLAMP



Here's a brand new time- and trouble-saver for the users of hydraulic hose and piping — Anchor's exclusive Split-Flange Clamp. Check these features — they're what you've been looking for.

LEAKPROOF — the "O" ring, successfully utilized in so many hydraulic applications, provides a perfect seal.

EASY TO ASSEMBLE — no unwieldy pipe wrench required. All you need is a small automotive type wrench. Ideal where clearances are limited.

ELIMINATES PIPE THREADS — can easily be removed or attached over and over again. No tapered threads or wedging action to cause distortion in pump housings, cylinders, or valve bodies.

WIDE RANGE OF SIZES AND TYPES — straight or angle styles with clamp or pressed-on couplings — sizes from ½-inch ID to 2-inch ID. Available for high, medium, or low-pressure service and suction return lines. Send coupon for further information.

ANCHOR COUPLING CO. INC.

Factory: LIBERTYVILLE, ILLINOIS • *Branch:* DETROIT, MICHIGAN

Tear out this coupon and mail today

ANCHOR COUPLING CO. INC., Dept. PE22
Libertyville, Ill.

Yes, I'm interested in Anchor Split-Flange Clamps. Please send me a bulletin with more information.

Name..... Position.....

Company.....

Company Address.....

City..... (.....) State.....

D-11

How to insure
Power Driven Equipment

Agitators or blowers, conveyors or elevators, printing presses or pumps — it's all the same no matter what you make. When power transmission fails, your whole machine or equipment gets blamed. It's *your* reputation as the primary equipment builder that suffers the loss.

As a safeguard, increasing numbers of design engineers are specifying Winsmith Speed Reducers. They know by reputation and experience that Winsmith can be depended upon . . . that each of their machines so equipped leaves their plant with power transmission unexcelled. They know also, that the Winsmith nameplate is a positive selling point — a mark of merit that has industry-wide recognition for top quality engineering and fabrication.

In selecting a speed reducer within the 1/100 to 85 h.p. range for *your* machines or equipment, profit from the experience of others. Select the one that is on the approved list of the world's most highly regarded companies — Winsmith.

For all the facts, request "Save Through Standardization" Folder.

WINSMITH
SPEED REDUCERS

MEMBER OF AGMA

WINSMITH, Inc.
111 Eaton Street
Springville (Erie County), N. Y.

two classes: piston pumps and rotary pumps. Under piston pumps, radial and axial piston arrangements are discussed with the assistance of photographs and drawings. Under the rotary classification, various types of gear pumps and vane pumps are given similar treatment. The elements of mechanical design and performance characteristics are thoroughly exposed.

Chapter six introduces a more involved treatment of the elements of fluid flow and prepares the way for a more thorough study of pump and motor theory. An understanding of the theory makes possible a more penetrating analysis of experimental data and the ultimate realization of sound pump motor design as shown in chapters eight and nine. Chapter ten gives a mathematical analysis of hydraulic clutches and chapter eleven exposes the limitations to the use of hydraulic transmissions systems.

There are three appendices at the end of the book: a bibliography, a symbol list, and a chart of dynamic viscosity conversion factors. At the end of each chapter are problems concerning the material covered.

An Introduction to Acoustics

ROBERT H. RANDALL, *associate professor of physics, The City College of New York.* 340 *pages,* 6 x 9 *in. Published by Addison-Wesley Press, Inc., Cambridge* 42, *Mass.* $6.

This book is intended to fill the need for a text that can be used at the intermediate level, as distinguished from the elementary and graduate levels, in the study of acoustics. A year of college physics and a year of calculus constitute the minimum of preparation for an understanding of the subject as presented here.

A previous knowledge of the complex notation, as used in alternating current circuit analysis, would also be helpful in visualizing some of the discussion. One chapter, however, contains a summary of the essential material in sufficient details to understand the text.

Although primarily a textbook for a course in acoustics, it will be of interest to engineers who are associated with the fields of communications and electroacoustics. Much attention is devoted to the more popular and applied features of acoustics. Among these are the physics of musical instruments, peculiarities of hearing, the design of radio loudspeakers, electronic devices as used in electroacoustical equipment, and the acoustics of auditoriums.

Recognizing the growing importance

in the use of electrical analogs in acoustics, the author believes that so useful a tool in this and in other branches of physics and engineering should be given more attention than is ordinarily afforded in an intermediate text.

Following an appropriate outline of the scope of acoustics and a definition of terms the subjects discussed include: Fundamental particle vibration theory, plane waves in air, waves in three dimensions, interference patterns, diffraction, acoustic impedance, behavior of horns, longitudinal waves in different gases, waves in liquids and solids, stationary waves, vibrating sources, musical instruments, reflection and absorption of sound waves, speech and hearing, sound measurements, experimental acoustics, reproduction of sound, and miscellaneous, applied acoustics. Exercise problems are included in each chapter.

Lectures on Classical Differential Geometry

DIRK J. STRUIK, *professor of mathematics, Massachusetts Institute of Technology. 221 pages, 6 x 9 in. Published by Addison-Wesley Press, Inc., Cambridge 42, Mass.* $6.

Developed from lectures for a one-term course in differential geometry, which was given for juniors, seniors and graduate students at the Massachusetts Institute of Technology, this book is the fourth in the Addison-Wesley Mathematics Series. Mr. Eric Reissner is the consulting editor.

In this text are presented, the fundamental concepts of the theory of curves and surfaces. These notions are also applied to a number of examples. The notation used in the Gibbs form of vector analysis. Some explanatory remarks are introduced in the text to aid the reader who may be unfamiliar with these notations.

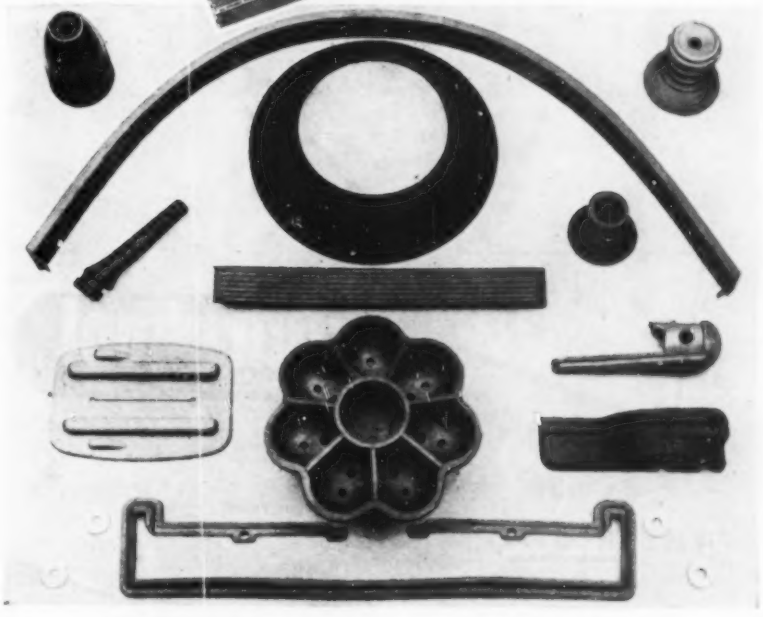
Much historical, biographical, and bibliographical material is included to enable the reader to refer back to original sources for further study.

Problems in the text have been selected in such a way that most of them are simple enough for class use; and often at the same time to convey an interesting geometrical fact. Some problems have been added at the end that are not at all elementary, but reference to the literature may here be helpful to readers who are ambitious enough to try those problems.

In addition to the main divisions or chapters that discuss curves, the elementary theory of surfaces, the fundamental equations, and geometry on a

Include Molded RUBBER Parts In Your New Product Designs

Write for a copy of the ACUSHNET RUBBER HANDBOOK. It contains helpful information, specifications, natural and synethetic rubber data, etc. Please make request on company letterhead.



When designing new products, or re-designing the old, consider the unlimited applications in which molded rubber now excels. Meeting functional specifications and multiple requirements beyond the limits of other materials, rubber gives the designer a welcome release from age-old restrictions.

ACUSHNET has worked with many customers in the initial stages of their designs when the collective specialized knowledge of our laboratory and engineering staffs has aided in obtaining the most satisfactory material, mold design and price. Our laboratory facilities are available to customers for the development of designs and compounds.

Acushnet
PROCESS COMPANY
New Bedford, Mass., U. S. A.

Address all communications to 768 Belleville Ave., New Bedford, Mass.

The Swing is to
Durakool
a dependable
10 YEAR SWITCH
Steel-clad with mercury to mercury contacts, the Durakool hydrogen filled switch is performing with sensational dependability.
★ Millions of contacts without a falter
★ Positive "Make and Break" contact action
★ Withstands high temperatures
★ No deterioration in storage
★ Seven new models—1 to 65 amperes
★ Smaller in size, increased capacity
Send for BULLETIN 525
Steel Durakool
MERCURY SWITCHES
See Telephone Directory for Local Distributor or write
Durakool, Inc. Elkhart, Indiana

THE RIGHT BALL
Has Licked Many a Problem...
Let Strom Help You
Not only in precision ball bearings, but in countless other places, Strom has found that the right ball will do the job better. Maybe your problem can be solved with the use of the proper ball. Why not take it up with Strom.
Strom has been making precision metal balls for over 25 years for all industry and can be a big help to you in selecting the right ball for any of your requirements. In size and spherical accuracy, perfection of surface, uniformity and dependable physical quality, there's not a better ball made.
Strom STEEL BALL CO.
1850 So. 54th Ave., Cicero 50, Illinois
Largest Independent and Exclusive Metal Ball Manufacturer

surface, one chapter is devoted to some special subjects. These subjects include envelopes, conformal mapping, isometric and geodesic mapping, mineral surfaces, ruled surfaces, and imaginaries in surface theory.

The excellent graphical technique employed in preparing the illustrations does much to stimulate the reader's understanding of the geometry associated with the propositions and principles set forth.

Testing of Measuring Equipment NBS Handbook 45

RALPH W. SMITH. 205 *pages,* 6 x 9 *in. Published by the United States Government Printing Office, Washington* 25, *D.C.* $1.25.

This volume deals with commercial measures and measuring devices, and includes descriptions of instruments, recommendations for the testing apparatus needed for their official examination, and instructions for their inspection and testing by weights and measures officials. It is a companion volume to handbook H37; taken together, these two handbooks are intended to provide practical instructions to weights and measures officials for the inspection and testing of all of the types of commercial weighing and measuring devices which such officials are normally called upon to examine. As was done in handbook H37, the present volume includes step-by-step testing outlines which supplement the several discussions on testing procedures. Also included, in the first three chapters, are some general comments relative to inspection and testing, which are applicable to all classes of commercial devices.

Human Relations in Supervision

WILLIARD E. PARKER, *Director Personnel Management Consultants, Chicago, and* ROBERT W. KLEMMEIER, *Director Moosehaven Research Laboratory, Orange Park, Florida,* 463 *pages,* 6 x 9 *in. Published by McGraw-Hill Book Co.,* 330 *W.* 42 *St. New York* 36, *N. Y.* $4.50.

Good human relations, whether in industry or in business, in the home or in the shop, are essential. The authors claim that good human relations can and should become a way of life, a philosophy of action, and have written this book with that thought in mind.

The book is practical and readable, and is designed to show the firstline supervisor how to deal with the prob-

lems in human relations which constantly face him. The book stresses the supervisor's role as a morale builder, and discusses the best practices in hiring, inducting, evaluating, and counseling the worker. The importance of understanding accident causes, effects of fatigue and monotony, job analysis, and evaluation is emphasized, and guidance is given the supervisor in achieving his own personal development. The text also contains illustrative material drawn from real life situations.

The author's approach is simple and practical, with occasional technical explanations given to broaden the understanding of the subject and support the practices being advocated. An extended study of psychoanalysis is not given.

The purposes, practices, and limitations of counseling are presented, with emphasis on nondirective counseling as a valuable aid to the supervisor if handled effectively.

Questions for discussions follow each chapter, and a complete list of motion pictures and filmstrips related to supervision supplements the text.

Theory of Perfectly Plastic Solids

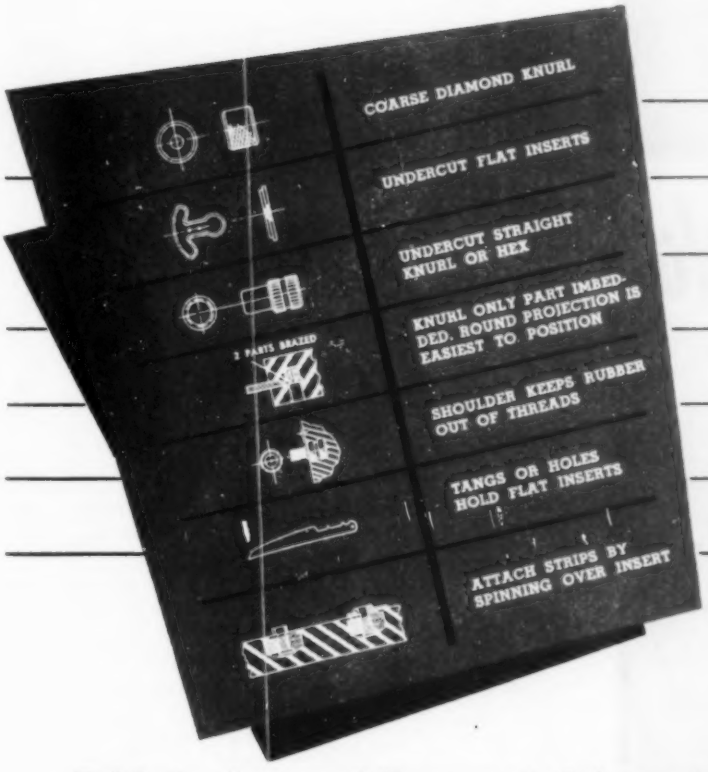
WILLIAM PRAGER *and* PHILIP G. HODGE, JR.: *Professor of Applied mechanics at Brown University, and assistant professor of mathematics at the University of California, respectively 264 pages, 6x9 in. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. $5.50.*

In spite of the early beginnings of the mathematical theory of perfectly plastic solids, only a very small portion of the material presented in this volume dates back by more than three decades. Much of this material is based on results obtained during the last five years. Some of the material on limit analysis is here published for the first time.

This book is not intended to be an exhaustive treatise on the general theory of plasticity. It is intended to be only an introduction to the particular branch of the subject known as the theory of perfectly plastic solids. This choice is motivated by the fact that this branch has most nearly taken definitive form, and that numerous results of practical importance to the designer are now available. Whenever possible, however, the authors have not hesitated to indicate what appear to be fruitful lines of further research.

Although written primarily for the research engineer and the student of

MATERIALS ENGINEERING FACTS


COARSE DIAMOND KNURL
UNDERCUT FLAT INSERTS
UNDERCUT STRAIGHT KNURL OR HEX
KNURL ONLY PART IMBEDDED. ROUND PROJECTION IS EASIEST TO POSITION
2 PARTS BRAZED
SHOULDER KEEPS RUBBER OUT OF THREADS
TANGS OR HOLES HOLD FLAT INSERTS
ATTACH STRIPS BY SPINNING OVER INSERT

hints for molding metal inserts in ACE HARD RUBBER...

It takes no less than 70 pages in the new Ace Handbook to cover the amazing versatility of Ace Hard Rubber! For instance, you'll find a choice of many different compounds . . . tensile strengths to 10,000 psi, dielectric strength over 600 v/mil, heat resistance as high as 300°F., water absorption as low as 0.04% . . . in molded parts, sheets, rods, tubes and linings . . . with complete (among world's largest) facilities for design, molding, extruding, finishing . . . for thousands of applications. Always check your Ace Handbook when selecting materials for today's production and tomorrow's plans. It's free—write today.

100th ANNIVERSARY

American Hard Rubber Company

93 WORTH STREET · NEW YORK 13, N. Y.

No Swing-
No Sway-
No Jerk...
The load moves easier for any electric motor with a Twin Disc Hydraulic Coupling or HYDRO-SHEAVE Drive. That's because, when starting the load from a dead stop, the "slip" of the hydraulic fluid permits the motor to accelerate fast from low rpm to working torque.
This smooth, cushioned acceleration eliminates jerking, eliminates swinging, eliminates swaying.
The pay-off comes in more work done, in less maintenance, in lower electric bills by leveling current surges.
Ask Calabar, Philadelphia Tramrail, Robbins & Myers, Whiting, or any other leading hoist manufacturer to show you their models equipped with Twin Disc Hydraulic Couplings. Or see your nearest Twin Disc Hydraulic Dealer.
TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES
TWIN DISC CLUTCH COMPANY, Racine, Wisconsin
HYDRAULIC DIVISION, Rockford, Illinois
BRANCHES: CLEVELAND • DALLAS • DETROIT • LOS ANGELES • NEWARK • NEW ORLEANS • SEATTLE • TULSA

engineering, the mathematical background expected from the reader is that necessary for advanced strength of materials or elementary theory of elasticity.

In addition to chapters devoted to basic concepts, trusses and beams, torsion of cylindrical or prismatic bars, and extremum principles, the subject of plane strain is covered in four chapters subdivided as follows: Problems with axial symmetry, general theory, specific problems, contained plastic deformation and limit analysis.

Studies in Large Plastic Flow and Fracture

P. W. BRIDGMAN, *Higgins University Professor, Harvard Univ.* 362 *pages,* 6 x 9 *in. Published by McGraw-Hill Book Co.,* 330 *W.* 42*nd St., New York* 36, *N. Y.* $8.

A reference work for advanced students, this book collects into a coordinated whole, the results of original experiments by the author on fracture and plastic flow. These have been accumulated during many years of experimentation under the unusual conditions afforded by pressure ranges much higher than those usually encountered in engineering practice.

Unusual and unexpected results have been found, sometimes in contradiction to theoretical expectations. Since the general subject of flow and fracture is not understood unless behavior under extreme conditions is taken into account, this book approaches the subject with a view toward increasing the reader's comprehension of the subject of flow and fracture in general.

The work covered in this book also includes much data that has appeared in government publications, some of which were classified. Some of these reports have been made available since the war only in the form of nearly eligible photostat copies.

Special emphasis is placed upon the effects of hydrostatic pressure in the range between 300,000 and 450,000 psi on the ductility of steel. It was found that the ductility of ordinary steels increased enormously when exposed to pressures of this magnitude. This introduces a new property of steel, the pressure coefficient of ductility, which is not disclosed by ordinary methods of testing and which has proved of considerable importance in ballistic problems.

Others of the many factors studied include the collapsing of heavy tubes under external hydrostatic pressure and plastic flow, under various sorts of stresses, of small specimens cut in various orientations from specimens

that had been subjected to plastic deformation of different kinds.

Although many of the experiments that are discussed were made with the explicit purpose of getting a better understanding of the phenomena of fracture under conditions of high stress and the phenomena of the large plastic flow that often precedes such fractures, a number of these investigations were made during the war with practical applications in mind.

Advanced Engineering Mathematics

C. R. WYLIE, JR., *professor and chairman of the department of mathematics and astronomy, University of Utah. 640 pages, 6 x 9 in. Published by the McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N. Y. $7.50.*

A coherently organized textbook that can be readily understood by engineers who have pursued the study of formal algebra and calculus. This book deals with those branches of mathematics with which an analytical engineer must be reasonably familiar to perform his work effectively.

Specifically, this text covers ordinary differential equations, Fourier series, operational calculus from the point of view of the Laplace transformation, separable partial differential equations and associated boundary value problems, functions of a complex variable, vector analysis, and numerical methods.

In addition to these primarily mathematical topics, some forty pages of the text are devoted to the application of differential equations to mechanical and electrical systems for studying the vibration of complicated mechanical configurations. This chapter deals with systems having one degree of freedom, the translational-mechanical system, the series-electrical circuit, systems with several degrees of freedom, and electromechanical analogies.

The chapter "Analytic Functions and Fluid Mechanics" deals with the stream function and the velocity potential, special flow patterns, the flow past the cylinder, the transformation of a circle into an airfoil, and the force on an airfoil.

Techniques of numerical computations are set forth in the chapter "Numerical Analysis." These include the numerical solution of equations, finite differences, the method of least squares, harmonic analysis, the method of Stodola, and the iterative solution of frequency equations.

So that the book may be reasonably self-contained, an extensive appendix is included. A knowledge of

WHAT ARE YOUR INDIVIDUAL NEEDS FOR A

HEAT EXCHANGER COOLER or CHILLER

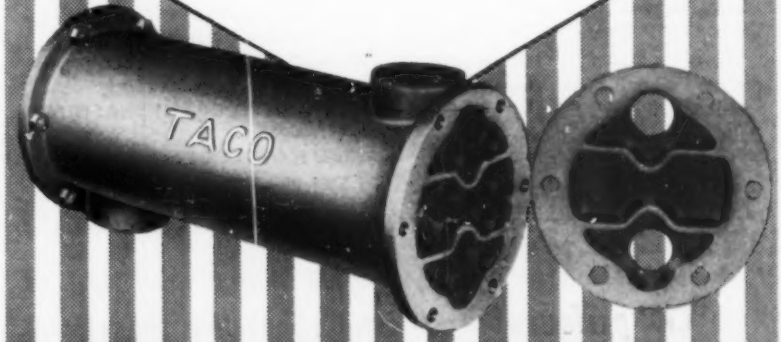
WHAT SHAPE? WHAT TYPE? WHAT MATERIAL?

for heating or cooling...

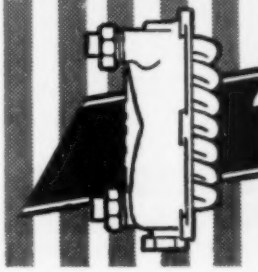
WATER • HYDRAULIC OILS • LUBRICATING OILS
COOLANTS • CUTTING OILS • OTHER LIQUIDS

Our engineering department will gladly assist you, just as it has numerous other organizations, in design and selection of proper exchanger for your particular requirements.

A heat exchanger specialist from the factory is immediately available. Just call Providence, R. I., GAspee 1-2600, wire or write.



Illustrated is just one of more than 100 different shapes we are making as component parts for manufacturers.



Taco

TACO HEATERS INCORPORATED
137 South St., Providence 3, R. I.

10-Horsepower

ONLY 97 lbs.

the ONAN CK ENGINE

STEP UP PERFORMANCE of your engine-driven equipment with this rugged, lightweight prime mover. The Onan 10 HP Twin-Cylinder "CK" engine is inherently smooth-running, delivers vibration-free power at all speeds. Alternate-firing, air-cooled. Built for long, heavy-duty service . . . with oversize bearings and rugged construction throughout. Unusually compact, to simplify installation.

CK Features

OPPOSED DESIGN: Lighter weight; vibrationless performance.
OVER-SIZE BEARINGS: Extra-large bearing area assures longer life.
PRESSURE LUBRICATION: Positive oil supply to all bearings.
SHORT, RIGID CRANKSHAFT: Fully counterweighted.
AXIAL FLOW COOLING FAN: Forces air over and around cylinders for maximum efficiency.
COMPACT: Fits into 2.9 cubic-foot space.

No other heavy-duty, 4-cycle engine matches "CK" performance in installations like these!

Kalamazoo Rail Car—The "CK" saves weight for easy handling. Runs smoothly at all speeds.

M-E Tiller—Out-performs any tilling unit of similar horse-power. Smooth-running, powerful.

Thermo-King Truck Refrigeration The lightweight, smooth running "CK" is ideal for this installation

Write for Specifications

Onan PRODUCTS

D. W. ONAN & SONS INC.

6802 UNIVERSITY AVE. S.E. • MINNEAPOLIS 14, MINN.

the subjects summarized here might well be considered a necessary prerequisite for a study of the book.

This fifty-eight page appendix covers material from the borderline between calculus, advanced calculus and theory of equations. In it are reviewed topics such as the elementary properties of determinants and matrices, partial differentiation, infinite series, the expansion of functions in Taylor's series in one or more variables, hyperbolic functions, and the gamma and beta functions. Numerous exercises are presented throughout the text. These range from formal problems of a purely routine nature to practical applications.

Ferromagnetism

RICHARD M. BOZORTH, *Bell Telephone Laboratories, Inc.* 968 *Pages,* 6¼ x 9¼ *in. Published by D. Van Nostrand Co., Inc.* 250 *Fourth Avenue, New York* 3, *N. Y.* $17.50.

This important monograph makes available for the first time a practical source-book for engineers and students covering the entire field of ferromagnetism—from the fundamental magnetic particle, the spinning electron, to the complex alloys that have permeabilities of more than a million times that of free space.

In the selection, organization, and presentation of this material, Dr. Bozorth has been guided by its practical usefulness to research workers, industrial engineers, and students. The fields of metallurgy, chemistry, physics, and electrical engineering are all represented. The presentation is mainly descriptive and non-mathematical when discussing materials. Emphasis is on the physical concepts when discussing theory. A feature of the book is the large number of illustrations, averaging nearly one per page, which serve to clarify the text and reveal relationships. Manufacturing methods are outlined, with special reference to materials of commercial importance such as the permalloys, grain-oriented silicon iron, the alnicos and the ferrites.

Presented in four main divisions, Part I is introductory, covering concepts of ferromagnetism and factors that affect magnetic quality. Part II is a systematic description of the magnetic and related properties of known ferromagnetic materials. Part III is devoted to the physical phenomena of ferromagnetism. The data are interpreted by means of the domain theory which, in recent years, has made great strides in the interpretation of

Control YOUR WIRE TERMINATION EVERY STEP OF THE WAY

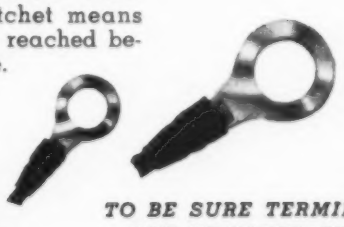
TO BE SURE CORRECT TERMINAL WILL BE SELECTED

Color code of each AMP PRE-INSULATED* terminal tells wire size range at a glance. 22-16 red, 16-14 blue, 12-10 yellow. A.W.G. and Navy wire ranges are also stamped clearly on tongue.

only AMP offers all these quality control features!

TO BE SURE PROPER TOOL WILL BE USED, AND TERMINAL NOT "UNDER CRIMPED"

Matching color code on AMP tool handles makes doubly sure that correct tool will be selected. And there is no chance for "under crimping"! Patented AMP CERTI-CRIMP* ratchet means correct pressure is reached before tool will release.



TO BE SURE TERMINAL WILL NOT BE "OVER CRIMPED"

AMP crimping notches are plug gauged to .003" to insure *precision* crimp! Terminals cannot possibly be crimped too hard. Each tool leaves an actual "brand" or dot code to double check proper installation.

THE SAME OR SIMILAR OUTSTANDING CODE AND DESIGN FEATURES ALSO APPLY TO AMP PNEUMATIC HAND T... BENCH AND POWER PRES... AND AUTOMATIC...

*Trade-Mark

AMP Trade-Mark Reg. U. S. P...

Above AMP products are cover... by Patents or Patents Pending

In Canada: ONTARIO, R. M. HUTCHESON, 10 Hardale Crescent, Hardington, P. O. Toronto 15, Elgin 5647

QUEBEC, BRUCE C. WALLACE, 3275 Linton Boulevard, Apt. 9 Montreal, Belair 8345

AMP

AIRCRAFT-MARINE PRODUCTS INC.

2100 Paxton Street, Harrisburg 4, Pa.

Branches in principal cities

Available

for the first time...

a Full-Color Sound Film

STEEL WITH A THOUSAND QUALITIES

Scientific schools and groups of designers, engineers, metallurgists and technical societies can *now* secure the *free* use of this full-color sound film, the first produced in the steel foundry industry. Available in 16 mm prints, the film is a 37-minute tour of the modern plant of Lebanon Steel Foundry. The camera follows jobs from the blueprints on the project engineer's desk through steps of production to show, finally, a few of the many important uses of Lebanon quality Steel Castings. Write for information on this exciting and educational film.

LEBANON STEEL FOUNDRY
Dept. C, Lebanon, Pa.
In the Lebanon Valley

LEBANON
ALLOY AND STEEL
CIRCLE L **castings**

magnetic phenomena. Some of the more important contributions to this theory have come from the author and his associates at the Bell Telephone Laboratories. Part IV and the Appendices, describe various conventional and special methods of measurement of magnetic quantities, and tabulate the more important physical and magnetic properties of materials.

The Seamless Story

J. PERC BOORE *Baker Steel & Tube Co., 285 pp, 6 x 9 in. Published by The Commonwealth Press, Inc., 1507 De-Long St., Los Angeles 15, Calif.*. $5.75.

The author has had extensive experience in all phases of the manufacture and merchandising of seamless steel tubing. The story gives a thorough background about the tubing having no seams or welds, and is thought to be the first printed matter giving the complete story. It contains the history of the invention, the story of the inventors, the development of the product, biographies of the varied personalities which were and are the seamless tubing industry, as well as an outline of contemporary mills and how they developed into their present form.

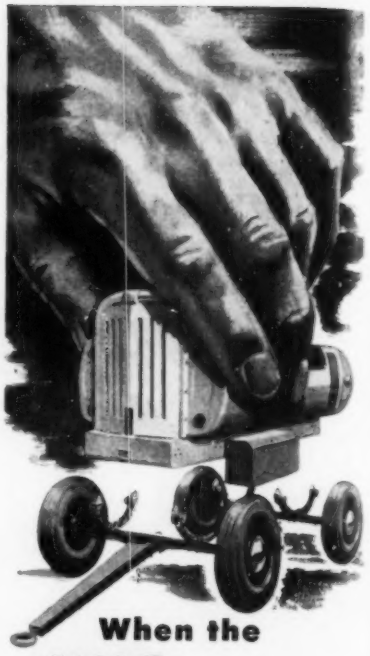
The first few chapters deal with the method used by the Mannesman brothers in 1885, and the Stiefel method which followed in this country in 1895. Illustrations help describe both processes.

Discussed to a great extent, in the remaining chapters devoted to the history in the United States, is the Shelby Steel Tube Co. of Shelby, Ohio, and the companies which it absorbed. Shelby is worthy of the title "Home of the Seamless Steel Tube Industry."

Finite Deformation Of An Elastic Solid

FRANCIS D. MURNDGHAN, *Ph.D., Instituto Tecnologico de Aeronautica (Technological Institute of Aeronautics) Brazil. 140 pages, index included, 6 x 9 in. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N.Y. and Chapman & Hall, Ltd., London, England. Hard cover, $4.*

This book presents a mathematical analysis, based on the Jacobian matrix theory, to show the relationship between the deformation of an elastic body and the forces exerted on that body. This method of study makes possible the consideration of squares and higher powers of the strain components in the theory of elasticity. The



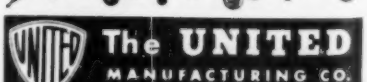
When the AXLE COUNTS . . . SPECIFY CARAVAN!

United CARAVAN axles provide **dependable mobility** for all types of portable equipment. These versatile units can be used on compressors, fire-fighting apparatus, pumps, concrete mixers, welders, generators, etc. as well as many types of military equipment.

CARAVAN axles can be furnished in two-wheel, single-axle assemblies and as four-wheel running gear equipped with automotive type steering mechanisms. Straight and drop axle type construction is available.

CARAVAN axles are engineered to assure smooth movement over high grade surfaces and maximum roadability over rough terrain. Controlled camber, toe-in and caster provide positive trail, regardless of speed or road conditions.

Write today for 12-page illustrated Catalog No. 101 containing specifications on the complete line of CARAVAN axles and describing automatic surge-control braking device, retractable third-wheel assembly and other CARAVAN accessories.



The UNITED MANUFACTURING CO.
221 W. Interstate St • Bedford, Ohio

Known Everywhere for Superior Performance

Packard

FRACTIONAL HORSEPOWER MOTORS

PACKARD ELECTRIC MOTORS for Washing Machines • Ironers • Driers • Dishwashers • Disposal Units • Water Pumps • Compressors • Power-Driven Bench Tools • Stokers • Furnace Blowers • Oil Burners • Ventilators • Milk Separators • Milking Machines and many other applications.

GM GENERAL MOTORS

Your products gain prestige when they are powered with Packard fractional horsepower motors. The Packard motor's name is so widely known—so greatly respected—that customers value your product more when they see it is Packard powered.

For more than thirty-six years, Packard has specialized in the manufacture of fractional horsepower motors . . . and built an outstanding reputation for uniformity of quality in motor products. Today, with greatly increased facilities for engineering and manufacturing, Packard can offer you more, in service and products, than ever before.

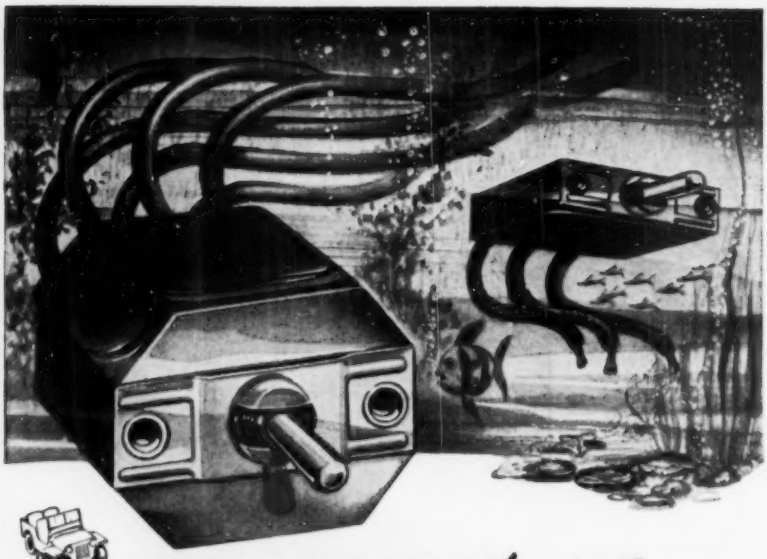
So take advantage of Packard's ability to serve you and your products now. Choose Packard fractional horsepower motors and get thoroughly dependable quality—while you win added prestige for your product.

Packard

REG. U.S. PAT. OFF. TRADE MARK

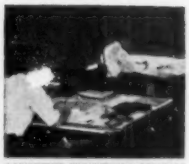
Packard Electric Division, General Motors Corporation, Warren, Ohio

DEPENDABLE APPLIANCE MOTORS FOR THIRTY-SIX YEARS



SWITCHES *that Swim*

Fishing for waterproof toggle switches? Then get your hooks into these! They actually open and close electrical circuits underwater . . . function perfectly from 65° below zero to 165° above . . . defy salt spray . . . and withstand shock and vibration!



COMPETENT ENGINEERING SERVICES

Riverside engineers developed the prototype of this switch to meet aircraft requirements, then modified it for present applications. It's being furnished now with ratings from 20 to 200 amperes, in toggle arrangements of momentary ON or OFF and stationary ON or OFF, with one or two hole mounting. Switch body is encased in a molded rubber compound developed to meet military specifications. Waterproof lead wires are vulcanized into the rubber case and become integral parts of the assembly, as does the switch mechanism itself. Waterproof connectors are assembled to the leads when required.

EXPERIENCED ASSEMBLY PERSONNEL

Perhaps now, or with further modification, this switch can put a "plus" into *your* product! Additional applications, better performance, "built-in" safety for an appliance or power tool . . . or to solve some other problem for you. Consult our engineers. They'll be glad to give you design and manufacturing recommendations for *any* intricate electrical devices or assemblies. Send specifications, prints or samples . . . today!

POSITIVE CONTROL OVER QUALITY

COMPLETE PRODUCTION FACILITIES

Riverside Manufacturing

AND ELECTRICAL SUPPLY COMPANY

10225 MICHIGAN AVENUE • DEARBORN, MICHIGAN • PHONE Tiffany 6-6800

WIRING HARNESSES AND ASSEMBLIES • CORD SETS • HEATER AND EXTENSION CORDS • ELECTRICAL SWITCHES • RELAYS • MOLDED RUBBER PRODUCTS

assumption is not made that deformation is so small that the squares and products of the strain components are negligible as is assumed in the classic infinitesimal theory.

The first chapter reviews the matrix theory and introduces its use in the development of relationships between differential equations of independent variables. The basis for the study of deformation of the elastic body is given in the 2nd and 3rd sections of this chapter where the matrix element of the arc in plane and space dimensions is explained.

Strain and stress relations are given in chapters two and three. Equations are derived through the use of matrix or vector quanities by which the virtual work of all the forces acting on any portion of a deformable medium in any virtual deformation can be obtained. From this analysis energy of deformation equations can be derived.

In chapters four and five, differentation is drawn between isotropic and non-isotropic elastic media and variations in the application of the matrix theory to solving problems involving each class of solids are explained.

The modified stress matrix used in problems involving simple shear and simple tension is offered in chapter six. Chapter seven is composed of particular problems and their solutions. Each chapter includes exercises for practicing the particular subjects covered.

Wavelength Tables of Sensitive Lines

L. H. AHRENS, *assistant professor of geology, Massachusetts Institute of Technology. 86 pages, 6x9 in. Published by Addison-Wesley Press, Inc., Cambridge 42, Mass.* $3.

Most of the content of this book consists of a collection table that list the wavelengths of the sensitive lines and the interfering lines that appear in the spectrum of beams of radiant energy emitted by the chemical elements. Wavelength tables are presented for sixty-eight elements. The tolerance of the data given should suffice for almost all grating spectrographs, and for prism instruments in the violet and ultra-violet ranges.

For most elements, the lines given as the most sensitive are believed to be correct, but those for a few elements and for a few rare earths are still in some doubt. This uncertainty is due either to a lack of consensus among analysts, inability to make theoretical predictions of the most sensitive lines, or merely a lack of complete information.